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THE
LARYNGOSCOPE.

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A REVIEW OF THE AVAILABLE LITERATURE ON THE LARYNX AND LARYNGEAL SURGERY FOR 1944.

HENRY BOYLAN ORTON, M.D.,
Newark, N. J.

The literature in 1944 is characterized by a large number of articles dealing with the effects of various sulfanilamides, penicillin and tyrothricin. These also play an important part in surgery of the larynx. Interest is high but we should not let it run away with definite established facts. In presenting this critical survey, I have tried to present a readable and practical survey of the articles pertaining to the larynx, as published in 1944.

WOUNDS OF THE NECK AND LARYNX.

Wounds of the neck come under two headings: First, those in which the great vessels are opened, and the patient succumbs in a matter of a few minutes; second, those in which the patient recovers and marvels at his miraculous escape. The first aid treatment in all wounds of the neck is to maintain airway and stop hemorrhage as soon as possible by digital pressure, which is only a makeshift; by an artificial hematoma, or by ligating the main artery with a loose loop. The dangers are: *1.* The severe reactionary or secondary hemorrhage; *2.* embolism; *3.* a spreading infection. The treatment is to explore as soon as the patient's general condition permits and the proper facilities are at hand; which means debridement, ligation of veins above and below, and repair

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of the nerves most generally involved; namely, the vagus, hypoglossal, spinal accessory.

Colonel Willard W. Schuessler[1] cites a very interesting case of self-inflicted excision of larynx and thyroid with division of trachea and esophagus with recovery. This patient, who was desirous of keeping out of the Army, thought that if he removed his larynx and could not speak, the Army would not accept him as a private. The article is accompanied with numerous pictures of the plastic procedures necessary in repairing the defect caused by the self-inflicted excision. The question of the possibility of growth of hair in the esophagus, as the result of the plastic procedures was discussed by the dermatologists and radiologists. It was decided not to use X-ray to prevent the hair from growing.

In many cases of laryngopharyngectomy, I have found it necessary to reconstruct the pharynx and esophagus after the procedures mentioned above; and in all male cases the hair has continued to grow; it does not cause any discomfort except when it is regurgitated and vomited. The treatment, of course, is to cut it off.—(EDITOR.)

R. L. Lewis[2] states that very little has been written regarding battle casualties. The mortality rate varies from 2.6 to 6.2 per cent. The author reports cases illustrating the various types of injuries and offers certain principles which should be observed; *i.e.*, relief of respiratory obstruction, arrest of hemorrhage and prevention of wound infection. He advocates local anesthesia in respiratory obstruction, when tracheotomy is indicated. (This is as it should be, for many a dyspneic patient may be made worse by a general anesthesia.) The feeding tube is also an essential requirement. Nerve injuries and fractures of the cervical vertebrae must be considered. With wounds of the large vessels, the patient seldom reaches the hospital. Infected wounds heal rapidly if laid wide open. Infection from emphysema as well as from direct extension may take place. This is a very good article and should be read by all interested in laryngeal surgery as well as surgery of the neck.

A penetrating shell wound of the neck involving the larynx is described by Major Brian Reeves,[3] who states that mortality in these injuries are high and that these cases are

seldom seen in hospitals. Symptoms are coughing, expectoration of blood and inability to swallow. The Major cites the case as follows: A tracheotomy tube was *in situ.* Large ragged exit wound in right side of neck extended and explored. The hyoid was fractured in several places, a large opening into the pharynx to the right of the base of the tongue, epiglottis injured. Debridement done. Pharynx sutured, rest of wound was left open.

The patient later developed a cervical abscess emptying into the pharynx. One month later, on direct laryngoscopy, the epiglottis was found to be slightly twisted anti-clockwise; edema of the left arytenoid extending to the aryepiglottic and ventricular folds on the left side, left cord not visualized. Later fixed in abduction. One month later, paralysis disappeared with restoration of function of the larynx.

The pathological anatomy: Shell took an upward and outward path entering the left side of the neck at the junction of the upper two-thirds and lower one-third of the anterior border of the left sternomastoid muscle, the exit being irregular, 1 cm. below the base of the right mandible. The fragment fractured the left superior cornu of the thyroid cartilage passing between the external branch of the left superior laryngeal nerve and the left recurrent. Damage to these appeared to be concussional. Fragment left the pharynx by tearing the lateral wall of the right vallecula and the right base of the tongue — hyoid bone fractured at this stage. A very interesting case.

The Jacksons[4] state that in trauma of the larynx tracheotomy is indicated in practically every case and should always be done low, preferably so that there are a few intact tracheal rings between the wound and the tracheotomy incision. Tracheotomy is indicated not only for the relief of dyspnea but also for the control of hemorrhage. With the airway thus maintained, compression of the neck may be employed to control hemorrhage; endolaryngeal hemorrhage can be controlled by direct laryngoscopic packing.

ASPHYXIA NEONATORUM.

In speaking about the pediatric aspects of asphyxia neonatorum, Alfred Biggs[5] gives the following outline for the treat-

ment of severe asphyxia of the newborn by the consensus of the best opinion on this important question:

1. Avoid severe cutaneous or other types of peripheral stimulation, such as hot or cold baths, spanking, swinging and dilatation of the anus.

2. Avoid manual types of artificial respiration. Opinion is now also swinging away from the infant Drinker respirator.

3. Keep the baby warm from the moment of birth.

4. Clear the air passages with direct laryngoscopic methods or by suction through a catheter introduced by the sense of touch.

5. If the baby does not breathe spontaneously, oxygen or a mixture of 95 per cent oxygen and 5 per cent carbon dioxide should be rhythmically forced into the cleared passages. This may be done with a controlled alternating positive and negative pressure apparatus or by the use of a rubber bag attached to the mask or by mouth to mouth insufflation or by the operator's breath through a tracheal catheter.

6. It makes little practical difference whether one uses oxygen or a mixture of 95 per cent oxygen and 5 per cent carbon dioxide.

7. Drugs such as epinephrine in the heart muscle or alphalobeline or nikethamide, subcutaneously, may be used if one is so inclined.

Some authors believe that none of these things are effectual in the initiation of respiration; however, few wish to assume such a helpless attitude.

In speaking about congenital laryngeal stridor, L. Schwartz[6] suggests the term "inspiratory laryngeal collapse" as being more appropriate than "congenital laryngeal stridor," where the accentuated infantile type of epiglottis is presented. Aryepiglottic folds and soft tissue over the arytenoids are sucked into the upper aperture of the larynx on inspiration, which causes obstruction. He further states that "expiration is free"; however, the condition may be so acute as to call for a tracheotomy or epiglottidectomy. The remedial measure is to release the suction of the epiglottis inwards

either by finger or Mosher's tube. In a well illustrated article the author brings out a new theory as to the underlying cause of this condition and the desirability of a change in terminology.

Although it is a well established fact that Lees was not the first to describe the typical condition which one associates with congenital laryngeal stridor, he apparently was the first to show the defective laryngeal mechanism which produces the stridor. Lees posed the problem of the underlying causation of the condition — a problem which remains unsolved today, even though the literature abounds with theories and writings relating thereto. It is to Lees' credit that he clearly stated the signs and symptoms of the condition and it is noteworthy that the ill-chosen name "congenital laryngeal stridor" was not proposed by him nor was it used in connection with the condition for years after his report.

Clinical manifestations and characteristics are borne in mind with description of the stridor. Respiration and nutritional disturbances.

A study of the epiglottis reveals the fact that several opposing forces are exerted on it; the anatomical basis of conception.

It is unsafe to assume that every afflicted infant will outgrow the condition at about the age of two years, albeit in most cases, which are those of less severe underdevelopment, this is true. In cases of severe laryngeal collapse, evidenced by marked inspiratory obstruction, a guarded prognosis is warranted since many fatal cases have been encountered. There is ever present the danger of aspirational complications. Nutrition is greatly interfered with. As the infant grows older the prognosis becomes increasingly better due to further mandibular development and consequent increased traction.

The reader's attention is directed to numerous treatises dealing with the correction of micrognathia by resort to orthopedic, orthodontic, surgical and other means. Undoubtedly these and other methods of dealing with this difficult problem are worthy of further study, but in the cases of severe dyspnea more direct and drastic measures applied to the site of obstruction are demanded if life is to be spared.

Two such immediate remedial measures are worthy of consideration when obstructive laryngeal dyspnea is profound and threatens the life of the infant: One is tracheotomy; the other is partial epiglottidectomy.

Partial epiglottidectomy apparently is not fraught with the grave risk that is generally believed to accompany this procedure. In one case he removed a small V-shaped wedge from the free edge of the epiglottis in the midline with no untoward results and with apparently little discomfort to the infant. This was accomplished through an infant laryngoscope and laryngeal forceps which removes such a V-shaped wedge. There was no appreciable bleeding, and no anesthesia was required. The child's condition improved immediately, and subsequently he appeared permanently relieved of his obstructive breathing. Where relief is not obtained so readily, consideration should be given to the removal of an even greater portion of the free edge by amputation. Some such procedure undoubtedly will be developed as the method of choice. The ideal approach will be that which breaks the obstructive mechanism while disturbing the normal physiology of the airway to the least possible degree. This approach remains to be developed. The article is freely illustrated.

STUDIES CONCERNING THE ACTION OF THE MUSCULUS CRICOTHYREOIDEUS.

Kurt Tschiassny[7] gives a historical review concerning the studies of the anatomy and mechanism of the action of the cricothyreoideus muscle. In his experiments on dogs, he found that stimulating the sternohyoid muscle draws the whole larynx and trachea downward. Stimulation of the cricothyroid muscle pulls the ring upward and laterally toward the stimulated side. Bilateral stimulation produces a jerking upward movement of the cricoid; the author states that cutting the sternohyoid muscle makes no change. These experiments have been cinematographed and have been shown at various meetings by the late Dr. Samuel Iglauer. They are very convincing.

Lieutenant Commander Joel J. Pressman,[8] speaking on the effect of the sphincteric action of the larynx on intra-abdominal pressure, stated that literature quoted indicates that the

larynx is capable of undergoing a closure which is sphincteric in nature and which represents a means of physiologically isolating the upper from the lower respiratory passages. This closure consists of forceful approximation of the true and false vocal cords of one side to those of the other. The sphincteric action comes into play in all expulsive acts, such as sneezing, coughing, vomiting or defecation, and in those muscular actions in which it is necessary to have the thorax fixed. It also closes during swallowing. In addition to the closure of the true and false vocal cords, a tier of closure is found at the level of the aryepiglottic folds.

The author further states that literature indicates that the closure of the laryngeal sphincter is valvular in nature, the resistance it offers to pressure from above or below being far greater than would be possible from a simple contraction of the muscles involved. The false vocal cords act as one-way valves preventing the egress of air from the trachea, and the true vocal cords as one-way valves preventing ingress of air. Pressure from below serves only to wedge the false cords together more tightly, thus increasing the efficiency of the valve, and pressure from above acts in the same way on the true vocal cords.

Original experiments demonstrated the effect of the action of the laryngeal sphincter on the movement and position of the diaphragm. Observations on the diaphragmatic movements occuring during comparable efforts to increase intra-abdominal pressure when the laryngeal sphincter was functioning and when it was deprived of its function revealed that on effort to increase intra-abdominal pressure the concurrent upward movement of the diaphragm was on the average twice as great when the sphincteric closure of the larynx did not take place. Thus, with the airway patent the volume of the abdominal cavity is comparatively increased by virtue of the elevation of the diaphragm during efforts to increase intra-abdominal pressure. This increase in volume tends to lessen the elevation in intra-abdominal pressure, all other factors being equal.

Correlation of these observations and the studies of the literature demonstrates the effect of the sphincter action of the larynx on the ability to increase intra-abdominal and

intrathoracic pressure and reveals the direct relation of this effect to the varied positions of the diaphragm when the airway is patent and when it is closed.

Stabilization and fixation of the diaphragm during attempts to increase intra-abdominal pressure are dependent in part on an occlusion of the airway such as occurs when the laryngeal sphincter closes. The same stabilizing effect is produced by occluding the airway at a higher level as in the Valsalva experiment, which consists of efforts to increase intrathoracic and intra-abdominal pressure by closure of the mouth and the nares. Under these conditions of respiratory occlusion a marked increase in intraabdominal and intrathoracic pressure can be brought about, but ability to increase the pressure is lessened under circumstances in which the airway is patent and diaphragmatic excursion, therefore, comparatively not limited. The anatomic structures within the larynx, chiefly responsible for producing these effects, are the false vocal cords. Thus closure of the larynx plays a most important rôle in all expulsive acts, such as vomiting and coughing.

Original experiments, controlled in various ways, demonstrated that the ability of a human subject to increase intra-abdominal pressure (as measured by bladder pressure) is about 19 per cent greater with than without the action of the laryngeal sphincter.

The increase of about 19 per cent in the ability to increase intra-abdominal pressure when the sphincter is closed is due essentially to fixation of the diaphragm, which in turn is dependent on trapping of air without the thorax. By this means a firm wall is established as the superior boundary of the abdominal cavity so that contraction of the abdominal parietes results in maximum increases of pressure within that cavity instead of the partial increase in volume that would occur in the presence of a mobile diaphragm. The trapping of air within the thorax by closure of the laryngeal sphincter valve prevents upward displacement of the diaphragm.

The pectoral muscle girdle is said to be dependent for strength of action in part at least on fixation of the thoracic cage from which the muscles have their origin. The laryngeal

sphincter valve is especially well devoloped in species which make extensive use of the forelimbs. Experiments showed no loss of strength in the pectoral muscle girdle when the human subject was deprived of the use of the laryngeal sphincter valve, and the theories which previous investigators had advanced relating to the action of this muscle group were not corroborated. The position of the diaphragm seemed to have no effect on these observations; however, the experiments leave room for doubt and the situation requires further study.

William Zerffi,[9] in an article on "Voice Production and the Laryngologist," is of the opinion that while some speech difficulties may be due to psychological factors, physical factors in voice, production, *i.e.*, laryngeal function, are of greater importance; and these factors should be considered to be in the field of the laryngologist.

BENIGN TUMORS OF THE LARYNX.

Papilloma: C. F. Ferguson and H. W. Scott, Jr.,[10] report 15 cases of papilloma of the larynx in children up to puberty, when as a rule they disappear. They advise that one should be suspicious of papilloma in any case of progressive hoarseness in a child. (He does not mention, however, that direct laryngoscopy should be done and biopsy taken, especially if unilateral cervical glands are enlarged, as a differential diagnosis of papillary epidermoid carcinoma of the larynx. I have seen such a case in a child 12 years of age.—EDITOR.) As in almost all the cases the papilloma disappears at puberty, conservative treatment as to surgery, irradiation, repeated excision, should be in order.

Mervin C. Myerson[11] is of the opinion that vascular polyp is the most common of growths occurring on the vocal cords. It is known variously as hemangioma, varix, inflammatory tumor, cavernous papilloma, angioma, hemangiectatic fibroma and papilloma, capillary angioma and pseudoangioma. He prefers the name vascular polyp. Vascular polyp is not a true growth but is inflammatory in nature. It is the result of trauma in the form of strain or abuse in the presence of chronic inflammation of the mucous membrane and the immediate subjacent tissue. Because vascular polyp is so distinctive, it is difficult to confuse with other benign growths of the

larynx. It frequently is called papilloma or fibroma: this is evidence of the perpetuation of erroneous nomenclature.

He further gives a history of the incidence in which the majority are males and mostly between 30 and 40 years of age. Vascular polyp, grossly, is usually single but may occur in two sites in the same larynx. The shape may be spherical, ovoid, cylindric, pyriform or nipple-like. The color may vary from reddish blue to grayish blue and they are usually confined to the anterior third. The Symptoms, Differentiation, Diagnosis, Prognosis and Final Treatment are described. Here the author preferred indirect to direct laryngoscopy. Indirect has advantages. The article is well illustrated.

Cystadenoma: Cystadenoma is defined by Frederick A. Figi, Willard D. Rowland and Gordon B. New[12] as adenoma that has undergone cystic degeneration. It is common in the breast and the ovary but extremely rare in the larynx. In fact, adenoma, from which it develops, is very unusual in this situation. A number of laryngologists of considerable experience never have observed a tumor with the microscopic diagnosis of simple adenoma of the larynx and some doubt its occurrence. Numerous mucous glands are present in the larynx, however, and at times these may give rise to a glandular cell tumor. Recognition of the stage in the transition of an adenomatous tumor at which it has sufficiently pronounced cystic features to permit of its designation as cystadenoma will naturally depend on the personal equation of the pathologist. The present report is based on four cases in which advanced cyst formation was present.

The results in these cases have been entirely satisfactory to date as regards both eradication of the lesion and restoration of the voice. Since removal of the tumors, periods of five months, three and two-thirds years, four years, and seven and two-thirds years have elapsed, respectively, and there apparently has not been any return of the tumors. It should be borne in mind that neoplasms of this type are very slow growing, and a period of several years might be required for a recurrence to attain sufficient size to produce symptoms; in fact, in one of these four cases a tumor that may well have been of this nature had been removed from the larynx approximately 20 years prior to the patient's coming to us.

Cystadenoma of the larynx is extremely rare. It apparently develops as a result of cystic degeneration of pre-existing adenoma of this structure. The symptoms and clinical course are those of any very slowly progressive benign laryngeal tumor. Removal by means of suspension laryngoscopy is the most satisfactory form of treatment in most cases, although laryngofissure may be necessary because of the extent of the tumor. With complete removal the prognosis is good.

Chondroma: Chondroma of the larynx clinically is benign but it becomes malignant by extension in continuity of structures. J. W. McCall, S. M. Dupertuis and F. S. Gardiner[13] in reviewing the literature state that chondroma of the larynx is rare; and that only 82 authenticated cases are known, to which the authors have added two of their own.

The most frequent site is the endolaryngeal surface of the posterior surface of the cricoid cartilage; next, the thyroid, the epiglottis and the arytenoids.

The chondroma appears as a solid immobile mass covered by normal mucous membrane.

Pathologically, it consists of somewhat atypical cartilaginous tissue which may undergo various types of degeneration.

The age range is from 15 to 81 years, but the highest incidence lies between 40 and 60 years. Males predominate four to one.

The symptoms are hoarseness, dyspnea, cough and occasionally dysphagia.

The subglottic situation of the tumors makes diagnosis difficult. Roentgenograms are of help. Figi stressed the prominent vessels standing out from a normal mucous membrane covering a sessile mass.

The treatment is always surgical — enucleation, if possible, laryngectomy if the growth is extensive. The operative mortality is high. Recurrences are noted occasionally, if any part of the tumor is left behind. The tumors do not metastasize.

Laryngocele: A ventricular laryngocele is reported by Marshall Taylor[14] in a white man, 35. Examination disclosed a tumor-like swelling, about the size of a tangerine, on the left

side of the neck, which extended above the thyroid cartilage and increased in size on coughing. The patient voluntarily percussed this external mass, which gave forth a tympanitic sound. Indirect laryngoscopy showed a swelling involving the left ventricular band, which at its greatest convexity projected beyond the median line of the glottis, occluding entirely the view of the left vocal cord. A Roentgen study established the diagnosis of ventricular laryngocele. On July 10, 1942, with the cooperation of Dr. Kenneth Morris, the tumor was successfully removed without rupture.

The patient had an uneventful recovery. The drain was removed on the third day, and the sutures were removed on the seventh day. Healing was completed at the end of two weeks. The wound was examined again after three months had elapsed; it was well healed with no evidence of the laryngocele. It was noted at this time that the patient's voice, which had previously been hoarse, was now practically normal in tone. Approximately two years later, on May 22, 1944, the patient was again examined. There was no evidence of recurrence of the cyst. Both the larynx and the voice had returned to normal.

Laryngeal Stenosis: Experiences in the surgical treatment of laryngeal stenosis due to bilateral abductor paralysis lead Klaus Vogel[15] to recommend tracheotomy as the treatment of choice for acute bilateral abductor paralysis of the larynx. Hofer's (quoted by the author) experiments have shown that the median position is due to isolated paralysis of the recurrent nerve, whereas cadaver position is due to the additional involvement of the external branch of the superior laryngeal nerve; therefore, it might seem justifiable to attempt division of this nerve for the condition.

Laryngologists have long recognized that surgery of the neck, especially thyroidectomy, is one of the most frequent causes of bilateral abductor paralysis of the larynx. Other conditions may also cause this condition.

Surgeons and laryngologists for years have been devising methods whereby these patients could have relief from their condition. Today, some form of arytenoidectomy, with fixation of the cord laterally, seems to be the operative procedure.

Orton[16] describes an extralaryngeal approach to the arytenoid. He further states knowledge of the part in question is necessary to allow the surgeon access with the least disturbance, and to enable him to carry out his task with as little effect on function as possible.

Trotter, after more than 20 years' experience, established the operation of lateral pharyngotomy by the transthyroid route, as a method of general usefulness in surgery of the pharynx and laryngopharynx. Unfortunately, this method or slight modifications thereof are not used as frequently as they should be; for instance, removing the lateral half of the hyoid bone enables one to have perfect access in removing a neurofibroma of the pharynx without contamination of the mucous membrane of the pharynx. Then by removal of the cornua of the hyoid bone and the lateral thyroid cartilage one has access to the laryngopharynx.

Orton[16] emphasizes a method of extralaryngeal approach to the arytenoid cartilage in performing arytenoidectomy for the relief of bilateral abductor paralysis. Removal of the posterior half of the thyroid ala gives adequate access to the arytenoid without entering the pharynx or the larynx. The first step in the actual attack on the arytenoid itself must be proper exposure. It must be remembered that the contraction of any scar tissue will be laterally and not mesially in the larynx.

It is a method of access: by removing the ala of the thyroid cartilage, the wall of the laryngopharynx is disclosed unopened; palpation can determine with a fair degree of precision the underlying conditions. From an anatomical and surgical standpoint, this operation gives an excellent exposure to the side of the neck, and the advantages are:

1. The lateral transthyroid approach gives a wider field of operation.

2. The longitudinal incision and splitting the sternohyoid and thyrohyoid instead of the transverse incision of skin and muscles.

3. Identification of the arytenoid cartilage by palpation beneath the laryngopharyngeal aponeurosis.

4. The arytenoid is under complete vision during the entire arytenoidectomy.

5. It eliminates the use of the laryngoscope.

6. It eliminates the difficulty and uncertainty as to where to make the window in the thyroid cartilage.

7. A direct extralaryngeal surgical attack to the side of the larynx.

8. Elimination of the feeding tube.

The procedure has proven very satisfactory, and from letters he has received from other men who have followed this procedure, their results have been very gratifying; they comment upon the ease with which the operation can be accomplished.

He also feels quite certain that the approach is sound and time alone will tell if arytenoidectomy is the solution to the problem of bilateral abductor paralysis.

Joseph D. Kelly[17] in a rather lengthy article describes some problems in the surgical treatment of bilateral abductor paralysis of the larynx; those who are interested should read the article in its entirety as it is a very well prepared paper.

CARCINOMA OF THE LARYNX.

The Pre-epiglottic Space: The manner of spreading a tumor at the base of the epiglottis and ventricular bands is well established by Leroux-Robert, and makes it probable that in a large number of cases the removal of the tumor cannot be accomplished with safety if the pre-epiglottic space is not removed as well as the larynx. By using a special clamp, Edmundo Vasconcelos and Plinio de Mattos Barretto[18] make it possible to remove the larynx and pre-epiglottic space in a single block, and the suturing of the pharynx, which is kept closed during the entire operation, becomes simple and safe.

(I am glad to see that the pre-epiglottic space comes out in all laryngectomies. Since 1938, I have been removing the hyoid bone, larynx and pre-epiglottic space in all my laryngectomies. In cancer of the larynx the prime motive of the surgeons is to cure the patient; this is best done by an inci-

sion wide enough to thoroughly and completely surround and remove the growth. We cannot appease or be conservative in treating cancer anywhere; not only in the larynx.—EDITOR.)

Louis Clerf[19] further emphasizes this very important space and factor in dealing with carcinoma of the larynx. It is one of the most important steps brought forward in the treatment of carcinoma of the larynx. Dr. Clerf is to be congratulated on again bringing it before the medical profession. All those doing operations on carcinoma of the larynx should study well the articles of Robert and Bisi.

LeRoy Schall[20] states that in properly selected cases, laryngofissure gives 75 to 82 per cent of three-year to five-year cures. In cases of Group II radical operation, *i.e.*, laryngectomy, is indicated. In such cases the patient should be trained in the development of the esophageal voice or in the use of an artificial larynx. Raul David de Sanson[21] also reminds us that laryngofissure constitutes the ideal treatment for initial cancer and preservation of the voice which is possible in many cases. For laryngofissure, local anesthesia with basal is used. The time required for operation is short and the loss of blood is avoided. Laryngofissure usually improves the voice as cicatricial bands substitute for the vocal cords. He stated in his article that out of 19 laryngofissures laryngectomy was necessary in five.

Daniel Cunning[22] gives a very clear-cut picture of the indications for laryngofissure and laryngectomy for intrinsic cancer of the larynx. All cases of cancer, no matter where, are operable in the beginning and it behooves us to treat and make early diagnosis of all intrinsic and extrinsic cases.

As to Roentgen therapy of carcinoma, although DaCosta's dictum should be carried out, namely, "Cancer should be operated on, if at all operable." You may combine this with surgical diathermy; but to turn all so-called extrinsic cases over for irradiation, in my opinion, is poor judgment.

W. E. Howes and M. Platau[23] give a review of eight years' treatment and end-results at the Brooklyn Cancer Institute. Early symptoms are taken up as well as classification. Methods of treatment: when localized operation offers the great-

est opportunity for cure. Lesions too far advanced are for irradiation; but they fail to state when a lesion is too far advanced for surgery.

Norman McCormick[24] states that while total laryngectomy undoubtedly cures the early cases of intrinsic cancer of the larynx, and also some of the extrinsic cases; I cannot agree with him when he says that it is a mutilating operation. Perhaps in patients using 7,500 to 12,000 r., over a period of 60 days with no improvement, and who are operated upon, mutilation may result. Surgery is still the operation of choice if surgically operable.

John Blady and W. Edward Chamberlain,[25] in treatment of cancer of the larynx by Roentgen irradiation, report five-year end-results and state that the treatment by irradiation in these patients was selected for one or several of the following reasons: *1.* Presence of metastasis in the neck on admission; *2.* disease process too extensive for surgery; *3.* suggested radiosensitivity of the tumor as determined by biopsy; *4.* advanced age and poor operative risk; *5.* complicating cardiac and renal disease; *6.* recurrence after laryngofissure; *7.* surgery refused by patient.

The physical factors of the radiating source employed in this series were as follows: 180 kv. (average), constant potential, 5 ma., 50 cm., target-skin distance, and in all cases 2 mm. copper plus 1 mm. aluminum filtration. A daily dose of 125 r., measured in air, was delivered through 10 by 10 cm. fields to each side of the neck at the rate of 5 to 6 r. per minute. A total of at least 3,000 r. was delivered to each skin field, necessitating a minimum of 24 consecutive days for the completion of treatment.

Max Cutler[26] in his article states that though radiotherapy was limited to inoperable cancers, the problem of choosing between operation and irradiation was relatively simple. Now that irradiation is conceded to be the method of choice for certain operable lesions, the problem has become much more difficult, and the responsibility for making a proper choice has greatly increased. With this change has come increased necessity for careful clinical and pathologic research in an effort to explore every factor that may help one in this decision. In rare instances the microscopic structure of the

biopsy specimen is of some help, but the information thus gained is of limited value, and the interpretation is hazardous even when supported by much experience. At best the biopsy can be interpreted only in the light of the clinical findings. With the exception of the radiotherapeutic test, the gross features of the lesion as seen on indirect and direct examination give the most reliable indications of radiosensitivity. The more movable the lesion and surrounding structures, the more likely it is to be radiosensitive and curable by radiotherapy. Infiltrating lesions that invade the underlying muscle and cause complete fixation are generally radioresistant, but here also exceptions occur. Notable examples are those lesions of the ventricle that destroy the thyroid cartilage and invade the pre-epiglottic space and sometimes perforate the soft tissues of the neck. These lesions are frequently radiosensitive and sometimes cured in spite of their infiltration and extent. One patient with cervical metastasis belonging to this group lived eight years without recurrence and died of cardiac disease; another is now alive six years after treatment. Both were treated by intensive irradiation.

The responsibility of advising radiotherapy instead of laryngectomy under certain conditions in which the opposing factors appear to be equally balanced is indeed a serious matter. The knowledge that if radiotherapy fails, laryngectomy may still be performed with safety is of considerable help. As one's experience accumulates, the decision becomes less difficult. Certain intrinsic lesions of the true vocal cord with subglottic extension and complete fixation have, with isolated exceptions, failed to respond to the most intensive radiotherapy. Consequently, the patient permitting, laryngectomy is performed if there are no general contraindications. On the other hand, I find more and more cases in which fixation of the cords is only partial and which have yielded excellent results with the present methods of irradiation. The details of these results are in preparation and will be published shortly.

The therapeutic test is merely a further effort to help one choose the best treatment for the particular cancer under consideration. The greatest care must be exercised not to withhold laryngectomy when that procedure appears to offer the best chance of cure. At the same time, due cognizance

must be taken of the advances and the results of modern radiotherapy in order to give the patient the advantage of cure without laryngectomy if the circumstances warrant.

The radiotherapeutic test presented has proven to be of value in testing the relative radiosensitivity of carcinoma of the larynx. The information gained by use of this test is of practical value in deciding between operation and irradiation under circumstances in which a decision is otherwise difficult. If the lesion shows a favorable response, the second cycle of treatment is administered; otherwise, laryngectomy is performed four to six weeks after the completion of the therapeutic test. The therapeutic test is the first phase of the "interrupted method" of treatment under the principle of concentration radiotherapy reported in a previous communication. Further experience with the use of this technique has been satisfactory and has confirmed the original opinion concerning its effectiveness.

(Experience here is an important factor especially those who do the so-called surgery for extrinsic cancer of the larynx; however, not many do this extensive work. In my experience, surgery still plays the most important part in cure of carcinoma of the larynx. In those cases, however, where nothing can be done, then X-ray therapy is palliative only.—EDITOR.)

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224 Delavan Avenue.

OTOLARYNGOLOGIC SYMPTOMS OF THE PSYCHONEUROSES.*†

F. W. DAVISON, M.D.,
Danville, Pa.

INTRODUCTION.

Judging by the scarcity of papers dealing with this subject, one might be tempted to generalize and say that most otolaryngologists are not interested in psychosomatic medicine. A review of the *Transactions* of the American Laryngological, Rhinological and Otological Society, Inc., for the last 10 years reveal no papers dealing with the so-called functional diseases with the exception of two excellent papers by Dr. J. S. Greene describing speech abnormalities. The otolaryngologic literature in general is singularly deficient in papers dealing with the psychosomatic problems in our field. Noteworthy exceptions are the paper by Dr. Clerf and Dr. Braceland,[1] "Functional Aphonia," and the paper by Dr. S. H. Kraines,[2] "Mechanism of Treatment of Neurotic Symptoms Especially of the Ear, Nose and Throat."

Because of the increasing number of patients with neurotic symptoms, I have of necessity become interested in the psychosomatic aspects of otolaryngology. War conditions have increased the number and intensity of the emotional problems responsible for so many of these so-called functional diseases. My own statistics showing the incidence of functional diseases are given in Table 1.

TABLE 1.

Number of NEW cases examined in November 1944	67
Children	17
Adults	50
Adults having only functional disease	18 or 36%
Adults having only organic disease	21 or 42%
Adults having both organic and functional disease	11 or 22%

It is obvious that without some knowledge of the etiology, diagnosis and treatment of the functional diseases, I am

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†From the Department of Otolaryngology and Bronchoesophagology, the George F. Geisinger Memorial Hospital, Danville, Pa.

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incompetent to advise more than half the adult patients who come to me for advice and treatment. It is necessary for us as otolaryngologists to have some insight into the mechanism by which emotions are translated into symptoms. Cannon[3] says the cults of mental healers which have grown to extraordinary proportions are probably a measure of the failure of the medical profession to consider adequately the rôle of emotion in producing bodily disorders.

A true indictment by Appel[4] recently published in a popular lay magazine reads as follows: "Today the family doctor has largely vanished from our cities. Instead we have specialists who have neither the time nor the understanding to consider the whole man."

Our patients suffer, and our reputations suffer if we fail to understand the emotional tension responsible for the local ear, nose or throat symptoms which bring the patient to us.

My purpose in writing this paper is to call attention to the symptoms of these neurotic patients which make them consult an otolaryngologist. It is up to us to make a prompt and correct diagnosis, rule out organic disease by adequate yet inexpensive methods of examination, give tactful advice, and if necessary refer the patient to an ethical and competent psychiatrist.

The following paragraph by Kraines[2] states briefly the mechanism by which these symptoms are produced. "Generally speaking, one may say that psychoneurotic symptoms result from emotional disturbances. These emotional disturbances may be relatively acute in an otherwise stable person, or as is so often the case, they may stem from a chronic lifelong instability of personality. They are translated into symptoms by means of: *1.* Tension, primarily in the autonomic nervous system, and by *2.* symbolism."

The following books have been of assistance to me in gaining some knowledge of the subject: Psychosomatic Medicine (Weiss and English[5]), Fundamentals of Psychiatry (Strecker[6]), Psychotherapy in Medical Practice (Levine[7]), Psychosomatic Diagnosis (Dunbar[8]), Nervousness, Indigestion and Pain (Alvarez[9]), Managing Your Mind (Kraines and Thetford[10]) and Therapy of the Neuroses and Psychoses (Kraines[16]).

BASIS OF SELECTION OF CASES.

In an effort to learn something about the problem, I have reviewed the case histories of 100 patients who were referred for diagnosis or who consulted our otolaryngologic clinic for relief of symptoms which by methods now in use were diagnosed "functional" in origin. Patients who had somatic disease in addition to psychopathology were excluded from this group, except those whose organic disease was thought to be the direct result of nervous tension. Of course many patients were seen who had both organic disease and psychogenic symptoms.

In addition to the chief complaint which made the patient request otolaryngologic examination, all of these patients had numerous other neurotic complaints which could be quickly elicited and which helped to confirm the diagnosis. The most frequent of these associated symptoms were insomnia, anorexia; itching, localized anywhere; spasmodic dry cough, palpitation, heart consciousness, feeling of weight on the chest, gas and belching, constipation, general nervousness and loss of weight.

The chief symptoms may be most conveniently considered by grouping them according to their anatomical locations. The incidence of symptoms in various anatomical locations is shown in Table 2.

TABLE 2.

1. Head and face	11
2. Ear	12
3. Nose	5
4. Mouth and tongue	4
5. Throat and neck	42
6. Larynx	10
7. Esophagus	16
Total	100

There were 30 males and 70 females in the total group.

TABLE 3. NUMBER OF PATIENTS IN EACH DECADE.

1-10	0
11-20	6
21-30	21
31-40	28
41-50	21
51-60	17
61-70	7
Total	100

Please note that the highest incidence of psychoneurotic symptoms is in the third decade.

TABLE 4. HEADACHES AND PAIN IN THE FACE.

CHIEF COMPLAINT.	
"Burning feeling in the head, face and mouth"	1
"Headache"	1
"Tight feeling in the head"	1
"Burning feeling in the forehead"	1
"Pain in right side of face and forehead"	2
"Pain in back of head"	2
"Pain in forehead"	1
"Pain in forehead and pain in the face"	1
"Pain in left side of face when nervous"	1

DISCUSSION.

The diagnoses applied in this group were: psychoneurosis, three cases; neurasthenia, two cases; constitutional inadequacy, three cases; anxiety neurosis, two cases; and unclassified psychosis, one case.

The diagnostic label is probably unimportant and from the all too brief life history which was usually taken was probably inaccurate. The important thing is to recognize that the symptom is a manifestation of tension which has its origin in emotional disturbance.

Judging by the current literature there is no standardized widely accepted classification of the psychoneuroses.

The fact that in some cases the pains were accurately described and sharply lateralized and did not tend to migrate made us take every precaution to rule out organic disease. Some of these patients were referred in order to rule out sinus disease because the symptoms had baffled the family physician. Some of the patients in this group had a definite phobia of sinus disease because of the anatomical location of the pain and the persistence of the symptom despite treatment which, needless to say, had not been directed at the cause.

Local treatments considered by some to be a legitimate placebo are perfectly useless (in such cases) and serve only to fix the symptom more permanently in the area treated. Weiss and English[5] state that treatment by drugs, by standardized mechanistic measures or local interference by surgery, for an illness which is emotional in origin only leads to a prolongation of the illness and to more confirmed invalidism.

TABLE 5. EAR. CHIEF COMPLAINT.

"Dull ache in the ears"	1
"Pain in and below the left ear"	2
"Hissing sound in the right ear"	2
"Dizzy spells"	3
"If right ear would only discharge, my nerves would be all right"	1
"Itching in the ears"	1
"Buzzing in the ears makes me a nervous wreck"	2

DISCUSSION.

It is, of course, impossible to prove that these patients did not have some biochemical disturbance responsible for their symptoms; but in each case the ear, nose and throat examination was negative, the audiogram was strictly normal, and there were other definite and easily elicited neurotic symptoms. Charts of most psychoneurotic patients are characterized by multiple admissions to the hospital and by many outpatient visits to several departments. A few patients had a marked phobia of mastoid disease or of deafness; several patients gave a history of so-called nervous breakdown. The emotionally stable individual may have a little tinnitus but does not bother to consult a physician; a neurotic patient with the same degree of tinnitus will complain bitterly.

TABLE 6. NOSE. CHIEF COMPLAINT.

"Odor of pepper in the nose"	1
"Burning feeling in the nose"	2
"Hot feeling in the left side of the nose"	1
"Sneezing and watery nasal discharge"	1

DISCUSSION.

The patient with sneezing and watery nasal discharge was included in this group because the onset of symptoms was sudden and severe at the time she was putting her son on the train to go overseas. There was no history of previous allergic symptoms. It is my opinion that vasomotor rhinitis and other symptoms of so-called intrinsic allergy are frequently due to emotional tension disturbing the balance of the autonomic nervous system, but at this time I have insufficient statistical proof. Vasomotor rhinitis resulting from emotional disturbance is analagous to excessive perspiration resulting from nervous tension. Several of these patients also had a marked cancer phobia.

There is an excellent brief clinical description of psychosomatic medicine by Leland Hinsie in the May, 1944, issue of the *Medical Clinics of North America.*

Hinsie[11] states, "While the stomach is a favorite organ in which to lodge the emotions, the eyes and nose run a close second. The best talents of the ophthalmologist and rhinologist fail to remove symptoms for the simple reason that neither lens nor resection of a septum touch the emotions. It is only too well known that 'sinus' (of hypochondrial origin) survives all medical and surgical skills; indeed, the latter lend plausibility to and perpetuation of the symptoms."

TABLE 7. MOUTH AND TONGUE. CHIEF COMPLAINT.

"Bad taste in the mouth"	2
"Burning feeling in the tongue"	1
"Dry mouth"	1

DISCUSSION.

These people consulted a physician not because of the severity of their discomfort but because the persistence of the symptoms made them think they had cancer.

TABLE 8. THROAT AND NECK. CHIEF COMPLAINT.

"Burning feeling in the throat"	5
"Lump in the throat"	16
"Tight feeling in the throat"	2
"Choking feeling"	9
"Pain in throat"	2
"Discharge in throat poisoning my body"	2
"Something sticking in right side of throat"	1
"Drawing and pulling sensation in left side of neck"	1
"Pain in right side of neck"	2
"Pressure in Adam's apple"	2

DISCUSSION.

As Jackson and Jackson[12] state, globus hystericus, "lump in the throat," and the sense of constriction and choking are due to spasmodic contraction of the inferior constrictor or of the cricopharyngeus. I believe that spasm of the cricopharyngeus can also be a factor in the production of hypopharyngeal diverticulum.

A good generic term for this group would probably be throat consciousness. The diagnosis of psychoneurosis rather than globus hystericus was made when there were many other neurotic symptoms in addition to throat consciousness. It is again interesting to note in this group that in some cases the patient sharply lateralized the discomfort.

Symbolism in the production of psychoneurotic symptoms was illustrated by a divorced woman whose chief complaint

was pain in the throat. Brief questioning brought out the fact that some months previously her ex-husband, during a fit of rage, had choked her rather forcibly.

The emotional origin of lump in the throat was well illustrated by the case of the man, aged 35, who couldn't make up his mind to marry the girl he had been courting for eight years. The lump developed as the result of the emotional conflict precipitated by the girl's insistence on marriage even though he knew she had been unfaithful to him. At this point it seems appropriate to stress the fact that sexual difficulty is only one of several causes of nervous tension.

TABLE 9. LARYNX. CHIEF COMPLAINT.

"Can talk only in a whisper"	1
"Something shuts off my wind"	1
"Weak voice"	2
"Cannot talk normally"	2
"Choking attacks"	1
"Loss of voice"	1
"High pitched weak voice"	1
"Hard dry cough"	1

DISCUSSION.

There was one case of psychophonasthenia and one case of falsetto voice in this group.

It is not difficult to think of laryngeal spasm as an expression of tension in the autonomic nervous system, if we recall that in its phylogenetic development the larynx was a sphincter before it became also the organ of speech. Dr. Clerf and Dr. Braceland[1] have given us a complete description of functional aphonia, and Dr. Greene[13] has so well described speech disorders of psychogenic origin that these subjects need no further discussion.

TABLE 10. ESOPHAGUS. CHIEF COMPLAINT.

"Difficulty in swallowing"	13
"Gas and pain in the chest"	1
"Pain in the chest"	1
"Orange seed stuck in the throat"	1

DISCUSSION.

In this group there were 11 cases of cardiospasm and five cases of cricopharyngeal spasm.

In each case the diagnosis of cardiospasm was confirmed by fluoroscopic examination and by esophagoscopy when

there was the slightest doubt. The history of dysphagia in these cases is not always clear-cut. From our experience it is evident that cardiospasm is one of the more frequently undiagnosed and neglected disease states.

The following brief case report illustrates the psychogenic factor in the production of cardiospasm.

A young man, aged 31, of nervous temperament was referred to me because of persistent hoarseness and difficulty in swallowing. The difficulty in swallowing developed after he had been told that he had laryngeal tuberculosis. The hoarseness was due to a small fibroma on one vocal cord near the anterior commissure. The dysphagia cleared up completely after removal of the fibroma, elimination of the tuberculosis phobia, and passage of a small mercury-filled esophageal bougie. I think in this case the passage of the bougie was also psychotherapy and that the satisfactory outcome was not the result of mechanical dilatation.

Dr. Walter B. Cannon[3] in an article titled, "The Rôle of Emotion in Disease," gives a clear picture of the alterations in physiology resulting from emotional disturbances. In support of the idea that cardiospasm originates primarily from emotional disturbance, Cannon says emotional disturbance due to worry or anger causes spasm of the cardiac sphincter, readily understandable because this sphincter is tightened by sympathetic impulses.

C. L. Jackson[14] reported that 40 out of 50 of his patients having cardiospasm stated that some emotional disturbance was the cause, and in his conclusion Dr. Jackson stated that psychoneurotic factors are probably of considerable importance as exciting and perpetuating causes in most cases of so-called cardiospasm. My experience agrees with this statement.

Vinson[15] says the cause of cardiospasm is not known, but admits that symptoms may be intensified by psychic factors.

Under the heading, "Hysterical Dysphagia," Vinson discusses the Plummer-Vinson syndrome which he thinks is cricopharyngeal spasm with secondary nutritional deficiencies. As treatment he recommends passage of a sound accompanied by reassurance and states that the size of the sound is immaterial.

In a separate section he describes functional dysphagia and recommends psychotherapy without instrumentation. May it not be that functional dysphagia is cricopharyngeal

spasm of an insufficient degree to cause the nutritional disturbances which lead one to diagnose the Plummer-Vinson syndrome? I think our patients would receive better treatment if we would think less about diagnostic labels and recognize and treat the emotional tension causing the spasm or tension in the esophageal musculature at whatever level.

I still remember with much chagrin one of my earlier patients whom I thought had cricopharyngeal spasm, and who in reality had a postcricoidal carcinoma. X-ray examination did not reveal carcinoma. Esophagoscopy should have been done earlier.

The necessity of ruling out organic disease in all these cases is well evidenced by one patient referred to me by a psychiatrist. Her intermittent dysphagia of 20 years' duration had at first seemed to respond to psychotherapy. This time she had a prune pit lodged above a cicatricial structure in the middle third of the esophagus.

Recognition of the fact that neurotic symptoms are due to hyperactivity of the autonomic nervous system resulting from emotional disturbance as taught by Dr. Walter B. Cannon[3] affords a rational understanding of the subject for both patient and doctor.

CONCLUSIONS.

1. The so-called functional diseases make up a large part of the practice of the average otolaryngologist today.

2. At least an elementary knowledge of up-to-date psychiatry and of the principles of psychosomatic medicine is necessary for every otolaryngologist.

3. Cardiospasm is an example of organic disease which had its origin in nervous tension resulting from emotional disturbance.

4. Adequate treatment of cardiospasm includes psychotherapy and a consideration of the life problem of the patient.

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ANNOUNCEMENT OF THE SPRING REFRESHER COURSE IN OTOLARYNGOLOGY BY THE UNIVERSITY OF ILLINOIS, COLLEGE OF MEDICINE.

The fifth semiannual refresher course in laryngology, rhinology and otology will be conducted by the University of Illinois, College of Medicine at the College in Chicago, March 26 to 31 inclusive, 1945. While the course will be largely didactic, some clinical instruction will be included. This course is intended primarily for ear, nose and throat specialists. As the registration is limited to 30, applications will be considered in the order in which they are received. The fee is $50.00. When writing for application, please give details concerning school, year of graduation, and past training and experience. Address: Dr. A. R. Hollender, Chairman, Refresher Course Committee, Department of Otolaryngology, University of Illinois. College of Medicine, 1853 West Polk Street, Chicago 12, Ill.

DOES SINUS INFECTION AFFECT SINUS GROWTH?

HARRY C. ROSENBERGER, M.D.,*
Cleveland, Ohio.

In recent years otologists have increasingly accepted the explanation of Wittmaack for the pathologic pneumatization of the temporal bone. In this connection it is recalled that Wittmaack summarized the normal process of pneumatization of the temporal bone as consisting of three stages: First, the ingrowth of subepithelial connective tissue into the marrow spaces; second, the contraction of the subepithelial tissue; third, the sinking in of the epithelial covering. Interruption of this orderly process by foreign-body irritation or infection in the middle ear in early infancy results in the diploic, mixed or sclerotic type of mastoid rather than the normal pneumatic structure. Thus infection is admittedly a prominent factor in the causation of persistently infantile atypical pneumatized mastoids.

Some authors[1,2,3] either definitely affirm or imply that an analagous relationship exists with the paranasal sinuses. They would have us believe that the smaller of two frontals or of two antrums in the same individual is of lesser size because of the retarding effects of some infection in infancy either single and severe, or mild but often repeated. This may be true; it may be true as a general proposition or it may be true only for isolated cases in a series.

The purpose of this paper is to present evidence that Wittmaack's theory of altered pneumatization is not applicable to the paranasal sinuses as it is to the mastoid; yet it is possible that in isolated instances infection may be a factor in retarding sinus growth, but that it operates as a law may be seriously doubted.

Radiologists state that variations in the size of the frontal sinuses in one individual are quite common, whereas similar extreme asymmetry in the size of the antrums is uncommon. Now if it were true that sinus growth was uniformly

*From the Department of Otolaryngology of St. Luke's Hospital, Cleveland, Ohio.

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retarded by sinus infection in infancy and childhood, as is the mastoid, then it is most remarkable that it is the frontal and not the maxillary sinus that exhibits this marked asymmetry of development. This is remarkable for several reasons.

Although at birth the frontal sinus is still anterior ethmoidal in location, not invading the vertical portion of the frontal bone until the first or second year, and in spite of the slit-like form of the antrum at birth, nevertheless it is fairly stated that the frontal increasingly has the advantage of dependent drainage while the antrum is handicapped by unfavorable drainage. This being the case and considering the multiplicity of childhood colds, it is probable that many sinus infections, recognized and unrecognized, occur and particularly affect the antrum because of its unfavorable drainage. Hence we would anticipate more antrum than frontal infections and on the basis of the Wittmaack theory would expect to see greater asymmetry of the antrums than of the frontals; however, the clinical facts show that we find the frontals more often asymmetrical while the antrums are the more often infected.

Further, it is questionable whether it is valid to compare the process of pneumatization that obtains in the mastoid with that operating on the paranasal sinuses excepting the one common factor of positive atmospheric air pressure. Indeed, even this factor is doubtful as necessary for pneumatization, as the antrum and ethmoid cells are present at birth before the establishment of the respiratory function and the resulting positive air pressure in the middle ear and nasal passages. In the case of the mastoid we find the middle ear, attic and mastoid antrum filled with an embryonal or myxomatous type of tissue in which the pneumatizing process is said to have its origin. No comparable condition exists for the paranasal sinuses.

Although both the mastoid and paranasal sinus bones have a common origin in intramembranous ossification and all contain marrow, yet there are important differences. One such distinction is the exclusively marrow-containing nature of the mastoid bone as contrasted with the maxillary bone which contains both marrow and tooth buds. Here in juxtaposition are two obscure forces, one unerringly guiding the teeth, each

to its proper position in the alveolus, and the other pneumatizing and fusing the marrow spaces to create the cavity of the sinus. In the case of the antrum, sphenoid and frontal it is strange but noteworthy that usually one large space is created by the pneumatizing process while in the mastoid and ethmoid discrete cells result.

Rhinologic literature contains important articles bearing on this whole subject. Schaeffer[4] and Sedwick[5] state that there may be considerable asymmetry of the antrum on the two sides of the same individual and for our purposes this is the important comparison rather than the variation in sinus size between individuals. Schaeffer also points out the greater asymmetry of the frontal in the same individual. This author also correctly draws attention to the obvious fact that until the permanent teeth erupt and the alveolar process develops there can be little room for the maxillary sinus. Consequently, retarded dentition may also affect the size of the maxillary sinus. This relationship of dentition and sinus growth has been commented on by Shea,[6] Berry[7] and VanAlyea.[8] Opposed to the statement of Schaeffer and Sedwick regarding the variability of size of the maxillary sinus in the same individual is the remark of Shea, with which I agree, that of all the sinuses the antrum is the most constant in development.

As to the size of the frontal sinus in relation to infection, Palmer[9] studied the histories, physical examination reports and sinus Roentgenograms of 262 normal adults. He could find no correlation between the size of the frontal and the number and duration of attacks of upper respiratory infection.

A study which is especially pertinent to the question of the effect of sinus infection on sinus growth is presented by Maresh[10] and Maresh and Washburn.[11] This study is comprehensive and utilizes the material of the Child Research Council of Denver. One hundred normal children were observed at approximately three-month intervals from birth to maturity. During this time, 3,501 sinus Roentgenograms were made of these children. In his first report, Maresh[10] states that a standard Roentgen technique was used, and special note was made of the increase in size of the sinuses together with the variations in size of the sinuses at different

age levels. Observations were made from routine antero-posterior Roentgenograms. Some of his conclusions were:

1. There are many variations in size and shape of antrums, frontals and ethmoids.

2. Usually growth was a uniform process for antrums and ethmoids.

3. The speed of the growth process of the frontal was very irregular compared to the antrums.

4. There were occasional differences in size of the antrums in some individuals but the differences were slight.

The second paper by Maresh[11] is of special significance because of the correlation between the purely objective Roentgen findings and the clinical history, covering the same 100 children considered in Paper 1. Among his observations were:

1. Of 64 children observed from the first to the seventh year of life, only eight showed differences in size of the antrums that were readily apparent by measuring the diameter of the two antrums. Seven of these eight children showed more than the mean percentage of films depicting pathologic antrums, while one showed less than the mean percentage.

2. In two children with asymmetric antrums it was the larger antrum that showed the pathologic changes.

3. The child having the most marked unilateral antrum involvement had antrums of equal size, though 19 of this child's 22 Roentgenograms, taken from one to seven years of age, showed only right-sided antrum changes. His antrums still were of equal size at age 12. Another child with every Roentgenogram from one to seven years of age showing right antrum involvement had equal size antrums at age nine.

4. If infection inhibited the growth of the antrum, one would expect to find the largest antrums in those children with the least evidence of infection, but such was not the fact.

5. Children with definite allergic manifestations showed a higher percentage (49 per cent) of Roentgenograms with pathologic sinuses up to six years of age than did a non-allergic group (38 per cent). After six years there was no essential difference.

6. Considering the group as a whole, a relatively constant per cent of the Roentgenograms taken between one to six years of age showed pathologic antrums; *i.e.*, about 32 per cent of all Roentgenograms examined. After six years of age the incidence drops steadily until it is about 15 per cent at age 12.

7. It is concluded that there is no definite correlation between the size of a sinus and the amount or frequency of infection in that sinus as seen in the Roentgenogram. It is further concluded that the size and pattern of growth of the sinuses is as much an inherent individual characteristic as the shape of the nose or the color of the eyes.

Salinger[12,13] quotes Bernfeld as also disputing the idea that Wittmaack's theory of altered mastoid pneumatization is applicable to the paranasal sinuses. Bernfeld considers that the vast number of infants suffering from colds and nasopharyngitis is out of all proportion to the small number who exhibit Roentgen evidence of arrested sinus pneumatization, were infection the chief cause of such arrested development. He, therefore, cannot subscribe to the theory that the pneumatizing power of the mucosa is amenable or sensitive to exogenous influences. He believes that the persistence of fetal red bone marrow is the dominant factor in the arrest of pneumatization and attributes the lack of transition from red to yellow bone marrow as the result of probable disturbances in the endocrine system. Both Carmody and Shea have mentioned this possibility in their writings on this subject.

Bernfeld states that he is convinced from his studies that disease of the mucosa has little, if anything, to do with the force, speed or degree of pneumatization. He also emphasizes that hereditary factors, in combination with their complicated rules, play a decisive rôle as to the constancy of the individual differentiation of the various pneumatized spaces. Shea makes a practical application of this idea in getting a preview of a child's adult sinus morphology by making a Roentgen study of the sinuses of the parent whose facial features he more closely resembles.

On the other hand, however diligently one may accumulate arguments to disprove the validity of a direct and uniform application of the Wittmaack theory (of pneumatization) to

the paranasal sinuses, one wisely admits that in the occasional instance sinus infection during sinus growth may alter that growth. Our present knowledge of what constitutes growth stimuli and of nature's checks and balances on the growth phenomenon are admittedly partial and immature. Certainly there is no basis for dogmatism. In the Developmental Growth Inquiry conducted at the Medical School of Western Reserve University, Todd[14] and Francis[15] have shown that scars, scorings and textural changes in the long bones provide skeletal evidence of the infections, faulty nutrition, and tissue insults that affect the human body. Similar fundamental research will enlighten us on the method, rhythm and vagaries of sinus pneumatization.

One such interesting vagary of sinus pneumatization is that seen in some cases of infantile hemiplegia. Dyke[16] and associates present a small series of such patients who exhibit excessive pneumatization of the ethmoids, mastoids, frontals and petrous tips on the same side as the brain atrophy. The cause of this excessive pneumatization is unknown, but it is surmised that its purpose is to increase the bulk of the skull at the site of the brain atrophy.

Because of particular interest in this subject it was decided to investigate a series of 163 private patients who had evident or suspected sinus infection. In each of these patients one to several Roentgen examinations of the sinuses had been made. I am indebted to Dr. H. L. Farmer, Dr. R. J. May and Dr. J. H. West, Roentgenologists, for the privilege of studying these Roentgenograms. Any variations in technique of these several Roentgenologists was disregarded, as the purpose was to compare the evidence of infection and altered growth between the right and left sinuses as revealed in the single Roentgenogram. In every instance standard views were taken of all sinuses, but in this investigation only the antrums and frontals were studied in the anteroposterior position. Of the 163 patients, 21 were in the age group from birth to 10 years; 34, from 11 to 20 years; while 108 were over 21 years of age. The sexes were about equally divided in all age groups.

Analyzing the observations it was found that:

1. Of the 163 patients only 53 per cent had symmetrical frontals, while 87 per cent had symmetrical antrums.

2. Of the 163 patients, 10 per cent had infected frontals, whereas 74 per cent revealed evidence of antrum infection.

3. Of the 163 patients, 9 per cent had aplasia of one or both frontals, while there was no instance of an absent antrum.

Two points are worthy of notice in this private series summary: One is the greater variability in size of the frontal sinuses in the same individual as contrasted with the greater uniformity of size of the antrums. The other point, and an important one, is the much greater frequency of infection in the more symmetrical antrum as compared with the low incidence of infection in the more variable frontal. Were infection a common cause of altered sinus pneumatization it would be reasonable to expect the greater assymmetry in the sinus which is more often the seat of infection.

CASE REPORTS.

Case 1: P. A. D., a male infant four weeks old, was first seen in June, 1937. There was swelling about the right eye, the right cheek and right upper alveolus. Bloody pus was discharging from the right naris and from a fistulous opening in the molar region of the right upper alveolus. Roentgenograms showed infantile antrums with the right quite cloudy. In ensuing weeks sequestra were discharged from the alveolar fistula and from the right naris. The diagnosis was maxillary sinusitis and osteomyelitis of the right maxilla. Sinus Roentgenograms made at the ages of three and seven years show some persistent thickening of the lining membrane of the right antrum but no essential difference in size of the two antrums. Both frontals are poorly developed.

Summary: Three and seven years after a severe antrum infection there is no gross evidence of disturbance of antrum pneumatization, though both frontals are markedly retarded.

Case 2: In July, 1937, B. T. R., a boy nine years old, following swimming and the extraction of a right upper tooth, developed severe cellulitis of the right cheek and eye. There followed an incision and drainage of an orbital abscess and a right intranasal antrotomy for empyema of the right antrum. There was loss of vision in the right eye and metastatic abscess in the right elbow. In November, 1938, a right external frontal operation was done and a sequestrum removed. Sinus Roentgenograms made one year and seven years after the antrum infection and operation show uniform and equal pneumatization of the two antrums, although the right reveals thickened membrane. The right frontal remains smaller than the left.

Summary: A boy acquires an infection of the right frontal and right antrum at the age of nine years. At this time the right frontal is smaller than the left and the antrums are of equal size. External frontal and intranasal antrotomy operations are performed. Roentgenograms made

one year and seven years after the sinus infections show the antrums of equal size without evidence of disturbed pneumatization, while both frontals grow but the right remains the smaller.

Case 3: In June, 1936, F. L. H., a girl aged eight years, was seen because of an infected left antrum. Roentgenograms showed an opaque left antrum with no probable difference in antrum size. The relative size of the antrum was difficult to estimate because of the marked opacity of the left antrum. The frontals were symmetrical. Because of persistence of symptoms in spite of various forms of treatment, a left intranasal antrotomy was done. Roentgenograms taken at the ages of 11 years and 12½ years showed some thickening of the membrane of the left antrum but no difference in size of the two antrums. The frontals remain symmetrical, though the patient developed a right frontal sinus infection and osteomyelitis of the frontal bone complicating scarlet fever at the age of 11. Recovery followed sulfonamide therapy.

Summary: An eight-year-old girl underwent an intranasal antrotomy for empyema of the antrum. Three years and four and one-half years later, Roentgenograms reveal no interference with antrum pneumatization. There was no evidence of arrested pneumatization of the frontal sinus one and one-half years after a frontal infection with osteomyelitis of the frontal bone.

Case 4: A white woman, L. M. H., aged 71 years, consulted me in January, 1943, because of purulent inflammation of the left antrum. Roentgenograms revealed definite aplasia of the left antrum as well as inflammatory thickening of its lining membrane. The present nasal symptoms began some six months previously, but the patient knows nothing of possible sinus infection in infancy or childhood.

Comment: A 71-year-old woman exhibits an infected, aplastic antrum. Some authors, correctly or incorrectly, believe this to be a common relationship.

Case 5: In August, 1940, a five-year-old girl, D. J. C., was seen because of a persistent head cold with much purulent discharge from the left naris. Roentgenograms of the sinuses revealed an opaque left antrum but the antrums were symmetrical in size. Proetz displacement and suction resulted in relief of symptoms and clearing of the sinus to transillumination after prolonged treatment. Roentgenograms made four years later in August, 1944, showed the left antrum still slightly cloudy but both antrums were equal in size.

Summary: A five-year-old girl suffers an acute and prolonged antrum infection as evidenced by clinical and Roentgen findings. Four years later, Roentgen study showed the antrums of equal size, though the originally infected sinus was still somewhat cloudy.

CONCLUSION.

As a general rule sinus aplasia is not a sequel of sinus infection, though such a relationship may occasionally occur, hence the Wittmaack theory of altered mastoid pneumatization may not appropriately be applied to explain altered sinus pneumatization.

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SPEECH HEARING TESTS.*

DOUGLAS MACFARLAN, M.D.,
Philadelphia, Pa.

FOREWORD.

A growing interest in the estimation of how efficiently people hear language warrants a review of past work in this field. Such a review will not only avoid some of the pitfalls for the tyro in testing, but will also save him much laborious experimentation. Further than this, a general comparison of materials and methods may be a step toward a more common acceptance of certain techniques. This means that more of us will be using tests that all of us can understand. Such an objective has been followed by the American Medical Association Council's Committee on Hearing Standards, although this work, up to this time, has been confined to pitch audiometry and to the standardization of hearing aids.

"The degree of deafness as determined by the audiometer does not give an approximate idea of the difficulty the patient may have in hearing the voice. It is the handicap for the voice that really counts."—SHAMBAUGH, SR.

"After all, what we and the patient are interested in is not the patient's ability to hear a tone reproduced through a telephone receiver but his ability to hear the spoken voice. It is common knowledge that some patient's appreciation of the spoken voice is better than the audiometer record would lead us to believe. It is my opinion, therefore, that audiometer tests leave the practical otologist dissatisfied."—WISHART.

"It must be remembered that the audiogram, which is a guide to the threshold for sounds at various frequencies, is no indication of the quality of perception at these frequencies." —P. M. T. KERRIDGE, *Vol. V, Reports on Progress on Physics, Phys. Soc., London, 1939.*

Speech is the most important thing with which hearing is concerned. Education and communication depend upon hearing and speech. Good speech depends upon good hearing.

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Speech, the English language as we use it and speak it, is an astounding example of carelessness and thoughtlessness. Often we do not say what we mean, nor mean what we say. Diction, inflection and intonation are scarcely considered by the average intelligent individual. This makes for an added burden on the person who is hard-of-hearing."

* * * *

The accurate measurement of speech-hearing has been an elusive objective for many years. With the advent of the Edison phonograph, there came the first speech audiometer, invented by Sohier-Bryant, but never generally popularized. With this machine, air-borne words were carried to the ears through stethoscope tubes; intensity was controlled by a valve which allowed an increase or decrease in air and sound volume.

Later came the electric phonograph with a pickup that activated a telephone circuit. Intensity was controlled by a rheostat. Prof. Bristol adapted the machine to test and to instruct deafened children in the Lexington Avenue (New York) School for the Deaf.

TABLE 1.

The First Hearing Test Record for Use with the Electric Pick-Up. Wm. A. Bristol and Miss Berry, of the Lexington Avenue School, 1926.

(Note the selection of monosyllables and words common to a child's vocabulary, short expressions, days of the week and numbers.)

Boys	Ball	Knife	Chair
Cow	Doll	Plate	Woman
Top	Hat	Spoon	Window
Dog	Man	Spool	Door
Cat	Girl	Sheep	Floor
Cup	Book	Baby	Good-morning
Pin	Coat	Paper	Good-afternoon
Fan	Boat	Dress	Good-bye
Shoe	Fish	Box	Thank-you
Sunday	One	Eight	Fifteen
Monday	Two	Nine	Sixteen
Tuesday	Three	Ten	Seventeen
Wednesday	Four	Eleven	Eighteen
Thursday	Five	Twelve	Nineteen
Friday	Six	Thirteen	Twenty
Saturday	Seven	Fourteen	

SPEECH FREQUENCIES.

As to the complexity of speech in regards frequencies, Dayton C. Miller, in 1916, analyzed the physical characteris-

tics of vowels. He reported, as one item, the presence of 10 important pitches in the word "a" as in "father." If this is true of one vowel in one letter, how complex must be the flood of frequencies that appear even in one short sentence! When one considers central perception, what a remarkable phenomenon it is!

Crandell studied and reported upon the regions of resonance of both vowel and consonant sounds, finding consonants considerably more complex than vowels. Fletcher used filtering frequency bands to see in which zones good hearing must exist in order to correctly interpret speech sounds. In the following tables, all the frequencies *below* the pitches noted have been eliminated from the telephonic circuit.

List showing extent to which upper frequencies are necessary for correct recognition of vowels and consonants:

Syllable	Lowest cut-off frequency consistent with 95 per cent intelligibility
s, z	5,000
t	4,500
th	3,800
ch	3,250
v, j, r	3,000
p	2,750
d, g, k, sh, oo (look)	2,500
h, y, m, b, a (tap) o (ton)	2,000
e (bet)	1,750
ng, r, i (tip) a (top) aw, oo (tool) i (time) a (tape)	1,500
w, ou (bout)	1,250
o (tone)	1,200
l, e, (team)	1,000

The following table by Fletcher gives the intelligibility caused by cutting off all components above a given frequency. One will note that consonants are greatly affected in eliminating pitches above 1,000 cycles.

Cut-off Frequency	1000—	2000—	3000—
Syllable	Percentage Intelligiblity		
e (team)	95	100	100
i (bite)	90	100	100
l	90	99	100
a (tape)	90	98	100
w	88	100	100
y	88	97	100
o (boat)	84	100	100
ng	84	100	100
u (boot)	85	98	99
ou (bout)	80	100	100

Cut-off Frequency	1000-	2000-	3000-
Syllable	Percentage Intelligibility		
i (bit)	80	99	100
o (bought)	80	98	98
h	80	95	98
m	72	98	100
r	70	99	100
d	75	91	99
b	70	97	98
j	64	88	96
u (book)	50	95	98
n	62	85	96
o (but)	50	95	98
v	57	86	95
k	40	88	97
sh	40	84	99
g	40	85	97
z	63	78	80
p	40	80	97
t	60	70	80
ch	40	72	93
f	24	63	85
th	30	52	66
s	40	46	42

The first electric phonograph established as a testing instrument was the "Western Electric 4-A Audiometer." This began to appear in the late "twenties" and early "thirties." It was primarily designed for group testing of school children and was operated by means of a spring-wound turntable which generated the small amount of electricity necessary to activate a network of 20 to 40 phones. The phonograph records used were lists of numbers (of three digits for the older children, two digits for the younger). Both male and female voices were employed. Attenuation was accomplished in the manufacture of the record by having the spoken words diminish in 3 db. intensity steps, from 30 db. above the threshold to minus 3 db. (The great advance in all hearing testing made at this time was the establishment of the decibel as a unit of hearing.) The children wrote the numbers heard, and were graded as to hearing loss by the hearing limits which their papers showed.

This audiometer has been widely used throughout the country in hearing surveys, and many million children have been tested in the course of 15 years. The method was crude, but simple and direct, and the work could be carried out by trained laymen. Re-examination of children showing poor performance was found necessary, for many of these children on careful retesting showed no loss. (The errors arose most often

from inattention, distraction or outside noise.) With all its faults and limitations, this instrument has accomplished a great good in the community. It has focused attention on early deafness and has caught many cases of unsuspected deafness.

TABLE 2.

Western Electric Test Numbers.

Phonograph Record No. 1: Loss (in db.)					Phonograph Record No. 2: Loss (in db.)				
30	526	538	863	646	30	463	853	541	466
27	348	363	224	662	27	525	436	285	868
24	414	318	546	648	24	624	841	115	543
21	111	868	288	624	21	432	218	821	225
18	648	338	883	331	18	856	444	118	262
15	536	182	416	462	15	416	483	662	444
12	826	548	813	452	12	688	441	431	622
9	363	351	345	126	9	466	183	284	445
6	528	351	588	831	6	844	238	431	388
3	634	588	133	833	3	338	661	123	642
0	124	565	471	554	0	641	488	822	816
—3	858	134	165	636	—3	166	463	238	531
Phonograph Record No. 3: Loss (in db.)					**Phonograph Record No. 4: Loss (in db.)**				
30	54	56	85	64	30	48	55	48	38
27	41	68	83	46	27	23	54	63	43
24	84	63	42	42	24	66	88	83	52
21	51	14	18	82	21	41	42	32	51
18	18	34	61	21	18	81	23	85	22
15	23	12	35	15	15	68	85	63	56
12	22	31	32	35	12	21	86	18	65
9	11	63	44	46	9	15	64	24	25
6	48	88	53	41	6	43	58	88	16
3	38	81	66	53	3	31	38	25	84
0	66	26	22	52	0	24	18	62	34
—3	51	12	45	84	—3	56	23	32	54

The records are standard sized, 12" in diameter, double-faced, Columbia No. 91687, No. 91691, and No. 91692, No. 91693. Playing time at 78 R.P.M. is four minutes. At the left of the above table appears the percentage hearing loss for the test numbers opposite; above the columns of test numbers are the symbols for female and male voice. The numbers at the tops of the columns are loud; they fade out in loudness toward the bottom of the columns. There are 132 testing stimuli (words) in the three-digit records, not including the —3 per cent hearing loss. In the two-digit records, there are 88 testing stimuli, not including the —3 per cent hearing loss.

Time interval between numbers is three seconds.

Table 3 represents the key used for the author's attenuated record. The test numbers used are represented by the first column in the squares; following each of these numbers are numbers showing the meter throw of the spoken numbers. Some idea may thus be had of the variability in the force of words. The Roman numerals represent the average intensity level for the four numbers in the square, *e.g.*, 1st Square: the

first test number spoken is "Five-Four" (not fifty-four), the meter throw for the "five" was 33; for the "four," 29. The intensity level for the four numbers in this square (Five-Four, Five-Six, Eight-Five, Six-Four) is 30 db. above the barely audible threshold.

TABLE 3.

The author's attenuated two-digit record.

54	33	29		18	23	17		48	8	5		48	
56	30	28	XXX	34	26	17	XX	88	7	6	VII	23	Normal
85	31	31		61	27	19		53	7	5		66	
64	30	30		21	18	16		41	9	7		41	
41	31	29		23	19	16		38	6	4		81	
68	26	22	XXVII	12	16	14	XVI	81	4	5	V	68	
83	27	24		35	16	15		66	5	2		21	Normal
46	29	22		15	19	18		53	5	2		15	
84	27	24		22	18	12		66	3	1			
63	22	23	XXIII	31	13	13	XIII	26	3	0	III		
42	23	22		32	14	11		22	2	2			
82	23	21		35	13	13		52	2	3			
51	24	24		11	14	12		51	3	3			
14	23	22	XXIII	63	9	9	X	12	3	1	III		
18	25	19		44	9	11		45	1	2			
42	25	19		46	12	8		84	1	3			

The author's attenuated three-digit record.

526		648		528		463	
538	XXX	338	XX	341	X	525	Normal
863		883		588		624	
646		331		831		432	
348		536		634			
363	XXVII	182	XVII	588	VII		
224		416		133			
662		462		833			
414		826		124			
318	XXV	548	XV	565	V		
546		813		461			
648		452		554			
414		363		858			
111	XXII	351	XII	134	III		
868		345		165			
288		126		636			

The importance of speech interpretability to the telephone industry has resulted in an enormous amount of valuable research by acoustic or telephone engineers in the past 25 years. This work has been published in the *Bell Laboratories Journal* and in the *Transactions* of special groups such as the American Acoustical Society. The radio and phonograph

industries have also added their quota of contributions. Much of this literature is so highly technical as to be beyond the scope of the average doctor's reading, yet, from it all, there has filtered down to us some useful and practical commonplaces:

Vowel sounds are heard twice as easily as consonant sounds.

Interpretaton of mistakes are due most frequently to a misunderstanding (mishearing) of consonant sounds.

Words, parts of words, individual vowels and consonants, vary greatly in their acoustic characteristics,—chiefly in their frequencies, and in their loudness. Thus, some words are more easily heard and understood than others.

The region of greatest hearing acuity lies between the pitches 300 and 3,000. The region of speech frequencies falls in the same zone. The most important hearing and speech area is at the upper end of this zone,—1,000 to 2,000.

Education, familiarity, mental acuity or agility, word memory and word association are a few of the factors of importance in good hearing. Noises, interruptions, distractions and cross-talk greatly interfere with hearing and with hearing testing.

In an initial study of speech-hearing made by the Bell Laboratories, there was used a large series of unintelligible sounds, not words, of the consonant-vowel-consonant,—consonant-vowel,—and vowel-consonant combinations. Lists of these words were called "Standard Articulation Lists." (See Telephonic Intelligibility, G. A. CAMPBELL, *Phila. Mag.*, Jan., 1910; I. B. CRANDALL: Composition of Speech, *Phys. Rev.*, 10, p. 74, July, 1917.) These *"selected speech sounds"* were meaningless. They were either spoken, or given from a phonograph recording, or through a microphone-telephone circuit. Such methods used for testing the efficiency of telephone circuits were called *"articulation tests."* "The percentage of the spoken syllables which were correctly observed was called the *syllable articulation.* This percentage has been frequently called simply *The Articulation"* (Fletcher). "The percentage of the total number of spoken sounds which are correctly observed is called the *Sound Articulation.* When attention is directed toward a specific fundamental sound,

such as b, t, a, then the term *Individual Sound Articulation* is used." (Similarly, *"Consonant Articulation"* and *"Vowel Articulation."*) (It is a question whether or not the selection of the word "Articulation" was well made; the common meaning referring rather to speech than to hearing. Yet, at this date, the special significance of the word has come to be accepted.)

When using words or short sentences for testing, Fletcher coined the terms "Descrete Word Intelligibility" and "Descrete Sentence Intelligibility," and remarked that "a new element enters in; namely, the thought or word associated with the word or sentence. Word lists have been worked out and used with some success. The main objections to the continuous use of such lists are: *a.* It is hard to make the lists equally difficult without resorting to very long lists of words; *b.* a very large number of lists are necessary to avoid memory effects. There is a distinct effort to make the standard articulation lists (meaningless sounds) as nearly like speech as possible. They must be representative of speech and they must be suitable for making tests. The early lists were (after experience) revised toward simplification.

"In setting up any testing list, it is necessary to classify and select a representative group of speech sounds. The National Phonetic Association uses a basic alphabet of 65 different sounds and uses also numerous modifiers which serve to distinguish slight variations in a given sound. Such a system is too complex for testing purposes. The revised scientific alphabet uses 48 simple sounds, of which 24 are consonants, 19 vowels and five diphthongs. Besides these 'Fundamental Sounds,' connected speech contains certain recurrent combinations of them, such as,—st, ing. Now, only type lists are used; the diphthongs, — i, ou, oi and ew are omitted from the new lists."

The author has made repeated efforts to utilize the Bell Laboratories' "Articulation Lists" of meaningless sounds and has found nothing but trouble and failure in them. The difficulty in reporting meaningless sounds heard, and the difficulty in recording or writing what is reported, is insurmountable. If considerable practice is undertaken by both "callers" and "observers," some little may be accomplished, but it is

a question if practice and familiarity are either fair or desirable in this type of testing.

Some years ago, Sir David Munro and A. W. G. Ewing (of Manchester, Eng.) were following this Bell method and submitted the test noted in Table 4. This will serve as a good example of the difficulties that arise in using unintelligible speech sounds.

TABLE 4.

The Victoria University of Manchester, Department of Education of the Deaf. New Standard Testing Lists.

Can you hear me say	sawp	vud	ped	bahn	wayzh	sest
Write down the word	choasp	beej	lut	footh	jesp	dawf
The next word is	zoov	dayg	jeel	yoaz	hoang	poam
Listen to the word	tum	maht	hayf	shawsh	gich	yud
I am now saying	pahb	faws	thamn	theesp	shawth	meej
Can you hear the sound	jath	shest	mib	nug	rul	thas
After that comes	lith	goan	zahs	chak	toop	chayth
Another word is	hosp	naz	woost	wayth	keeb	vit
You will now hear	cheeng	vooch	daj	lev	nahk	fon
I am now calling	kayf	thol	roch	lom	lov	zahsh
The following word is	wezh	rik	koazh	ting	thaz	boog

INTELLIGIBLE SPEECH TESTS.

It is common knowledge that inflection, accent, dialect and many other subtle characteristics of speech vary according to localities. The understanding of speech may depend greatly upon a familiarity with the speech of the locality. Consider a listing of but a few of language types:

The Southerner.
The Yankee.
The Mid-Westerner.
The Texan.
The East-Sider (New York City).
The Pensylvania Dutch.
The Swedes from Minnesota.
The Cockney Englishman.
The Oxonian.
The Yorkshireman.
The Cornish.
The Borderer.
The Scot.
The North and South Irishman.

Not only are the same words pronounced differently by these people, but many different and sometimes unfamiliar words are encountered.

Now, add to the problem, the foreign language accents as shown by even some of our second generation immigrants. It might appear, then, that worthwhile word lists for hearing testing were impractical. Certainly an Italian-American could most easily understand English words spoken with his accent, but a Pennsylvania Dutchman could not. A child from the "deep South" would have trouble understanding some of

the words spoken by a Mainer. It is gratifying to find, after years of speech-hearing-testing, that unfamiliar accent or inflection does not enter into the tests with the importance that might be anticipated. This is particularly true when numbers alone are used as test stimuli. "A study of the degree of toleration of speech inaccuracies permitted by the normal ear would be most revealing."—C. V. HUDGINS.

Numbers are probably the most familiar and most easily comprehended words in the language. This is shown by a 10 per cent better hearing performance with numbers than with other words. Since a certain amount of guessing is bound to

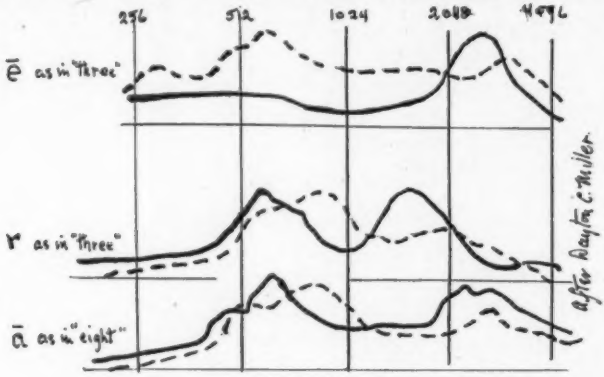

TABLE 5.

Solid line is male voice. Broken line is female voice.

take place when testing around hearing threshold, it is well to select only monosyllabic numbers, omitting, for example, "seven," and avoiding such words as "hundred," "thousand," "seventeen," "thirty." The numbers "one to ten," omitting "seven," will be found sufficient.

In the use of numbers there occurs a commonly recurring misinterpretation of "three" for "eight," and "eight" for three." Yet, the oscillograph analyses of the frequencies of the sounds involved show no similarity whatever.

Oscillograph analysis of the frequencies appearing when the sounds Ē, R and Ā are spoken, showed no correlation whatever, so that the analysis does not explain why "eight" and "three" are misinterpreted one for another.

In using numbers as test stimuli, the author prefers a constant level record, with the words all spoken at the same intensity. Loudness is then controlled by a decibel meter in the line. The examiner can use as many test words as he wishes at any intensity level.

In practice, it is advisable to "warm up" the patient's hearing by exposing him at first to words easily heard.

As a rule, a person can make a lower threshold in going from audible to inaudible intensity, than in coming from an inaudible level to audible. In short, a person seems to be able to some extent "to carry the sound down." It is interesting to record and to compare both testing techniques. The thresholds of the two methods are closer,—*1.* in good central acuity, *2.* in auditory alertness, and *3.* in nerve deafness as compared with catarrhal deafness. The thresholds of the two are farther apart in inattention, attention deafness, auditory disuse, and catarrhal deafness. If one ear is good, and the other bad, the poor ear may develop signs of poor central agility or acuity from disuse. Such an ear is often seen to improve in acuity, — in lower level hearing, when exercised for a few minutes with readily audible speech. Single tones do not seem to bring up this acuity.

The matter of the method of recording speech-hearing tests is important. In going from audible to inaudible, it is advisable to record the lowest or faintest level at which *all* test words are heard correctly. Then, continuing the attenuation, record the lowest level at which *any* word is interpreted correctly. Below the latter point, no words are reported correctly.

To obtain a comparison between "going from Audible to Inaudible" (A to I) with going from "Inaudible to Audible" (I to A), the following symbols are used:

A to I =
I to A =

Example:

A to I = 20 — 15 (all words heard at 20)
I to A = 20 — 25 (all words heard at 25)

The fallacy of using microphone speech, even though controlled by a meter, must be evident. One cannot be sure of

maintaining a definite speech level. For this reason, the old spoken voice test was in ill-favor. With carefully recorded speech a much "flatter" record may be obtained after considerable trials; and at least such variations as appear in it are always identically repeated. Before presuming differences in loudness level in the words of a record, one must realize that words differ as to their ease of interpretation.

WORD LISTS.

In selecting word lists for testing, it is well to use only the most familiar words in the language. Thus, there is reduced to a minimum the factors of education and intelligence. Thorndike's and Gates' list are most serviceable. From them can be selected the monosyllables, of which there are 406 in

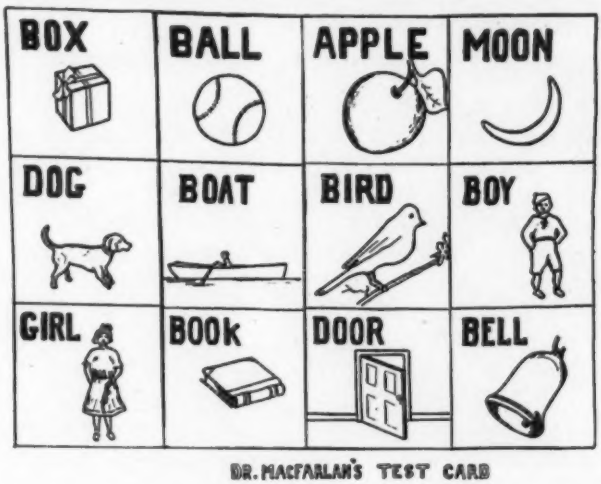

Fig. 1.

the first 500 words. Such a list gives a considerable acoustic variety to choose from, so that all consonant and vowel sounds may be represented. Table 6 represents a convenient list to be used with adults and with children above the age of five. Table 7 is an adaptation of the Crowden (University of London) method of testing children from ages two through four. The phonograph record on which these words are recorded is accompanied by a card illustrating the words. The child responds by pointing to the picture of the word heard.

TABLE 6.

Dr. Macfarlan's Test Method. 48 Common Monosyllables—Constant Level.

Boy	Green	Light	Play
Good	Bird	Hard	Milk
Cold	Blue	Burn	Stop
Hand	Lip	Horse	Train
Go	Ear	Look	Walk
Eat	Long	Girl	Man
Give	God	Head	Love
Love	By	Bear	Sun
Door	Big	Low	Tree
Child	Box	Ball	Two
Drink	Lost	Black	Now
Egg	Book	Home	You

TABLE 7.

14 Monosyllables for Preschool Child Test—Constant Level.

Box	Dog	Girl	Boy
Apple	Bird	Door	Ball
Ball	Boat	Book	
Moon	Boy	Bell	

Laila L. Larsen, of Indiana University, has recently (1943) made a comparative study and resumé of the hearing testing of school children. The clinical work has been voluminous but unfortunately has not been published. She has devised what seems to be a very practical speech-hearing test for little children. It closely resembles the Crowden (University of London) test.

LARSEN TEST.

"An R. C. A. recording machine is used" (phonograph with an electric pickup). The child is instructed to listen to the commands given over the earphone, and to follow them out (by pointing with the finger). Five speech intensities are graduated in descending levels of loudness.

Commands:

1. Show me your mouth. (8)
2. Show me your hand. (8)
3. Show me your ear. (8)
4. Show me your knee. (7½)
5. Show me your hair. (7)
6. Show me your arm. (6½)
7. Show me your neck. (6)
8. Show me your foot. (5½)
9. Show me your nose. (5)

"The first three commands are set at a fairly audible level even for slightly hard-of-hearing,—eight on the intensity dial of the machine. The dial settings for the other commands are noted." The exact decibel intensity level above threshold is not stated. The male voice is used.

ANOTHER RECORD FOR LITTLE CHILDREN.

This record is made for the purpose of testing little children between the ages of two and five. The words are spoken at the same intensity. To obtain the threshold of hearing, an intensity control must be used. A sufficient interval is allowed between the words to permit the child to answer what is heard. Naturally, words vary in force, in acoustic characteristics and in interpretability. All words are different in these respects. (This record was made by the author for the Philadelphia Public Schools.)

"Tell me what you hear":

Ball	Coat	Cat	Dog	Baby
Baby	Bird	Coat	Bird	Box
Box	Bed	Baby	Bed	Cat
Hat	Cup	Cup	Ball	Coat
Dog	Ball	Box	Dog	Bird

"Answer the questions":

Do you like candy?
How old are you?
What is your name?
Have you a brother?
Do you like the movies?
Have you a sister?
Where do you live?
What work does your father do?
What kind of ice-cream do you like?

"Repeat the words you hear":

Boy	Go	Door	Green
Good	Eat	Child	Bird
Cold	Give	Drink	
Hand	Love	Egg	

TESTING THE YOUNG DEAFENED CHILD WHO HAS A SMALL VOCABULARY.

Case: Dale P., age four, is a little boy born with enough hearing loss to have caused the acquisition of but few words that he either knows or can speak. The child's mother is instructed to collect the child's vocabulary for a week,—writing down the words. At the end of this time the child is readily tested by using these words over both the microphone and phonograph circuits. A decibel intensity control in the line gives an index of hearing level.

The words he speaks are used. It is presumed that he knows them best. In any event, these are the only words he can transmit back to me.

* * * *

Table 8 represents the key card used for a record containing a collection of 22 initial consonant sounds, each associated with five vowel sounds (Terminal consonants are disregarded, since they are both spoken and heard less well.) There is a space on the card to record the reporting made by the patient. The nature of the misinterpretations is of much value.

TABLE 8.

Dr. Macfarlan—Record No. 5074

CONSONANT LIST FROM THE PHONETIC ALPHABET—110 WORDS.

Date.....

NAME..... ..... Age.....

Intensity setting..... Distance.....

		Col. 1	Col. 2	Col. 3	Col. 4	Col. 5
B	1	Bed	Bird	Black	Book	Box
D	2	Day	Dark	Deep	Did	Die
F	3	Feet	Fire	Floor	Far	Feel
G	4	Girl	Go	Green	God	Get (yet)
K	5	Keep (disregard)	Kill	King	Kind	Can
L	6	Late	Long	Live	Look	Light
M	7	Man	Me	Milk	Mouth	More
N	8	Not	Now	No	Night	New
R	9	Red	Read	Rain	Ride	Road
P	10	Place	Pay	Plant	Poor	Put
S	11	Said	Saw	See	Send	Sit
SH	12	She	Ship	Short	Show	Shall
TH (soft)	13	This	Those	That	The	Them
TH (hard)	14	Three	Through	Think	Thing	Thank
T	15	Time	To	Top	Tree	Try
V	16	Voice	(Vie)	(Vote)	(Vine)	(Vim)
CH	17	Church	Child	(Chose)	(Chum)	(Chop)
Z	18	(Zee)	(Zoom)	(Zip)	(Zee)	(Zoom)
J	19	Just	(Judge)	(Joke)	(Jack)	(Jake)
H	20	Hand	Hard	Head	Help	Her
W	21	Warm	Wait	Want	We	Walk
Y	22	(Year)	Yet	You	Young	Your

The above words except those in parentheses are the monosyllables in the list of the first 500 in commonest use. Disregard the reportings on the first 10 words, and strike a % average for the remaining 100.

Record: Errors: Omissions:

Table 9 represents the recording of the "First Fifty Words" in frequency of use in the English language.

The frequency of the various vowel sounds in the list is as follows:

e	5	oo	4	a (make)	5	ou	1
e	7	o (on)	6	a (make)	2	u	3
i	2	o (no)	4	a (at)	4	u	2
i	6						

TABLE 9.

From Gates' List,—The First Fifty Words in Frequency of Use.

1-10	11-20	21-30	31-40	41-50
1. The	Make	We	Get	Had
2. I	One (adj)	It	To	Your
3. Is	One (noun)	Me	His	Give
4. To	Do	Of	Are	Mother
5. In	For	My	Her	Up (prep)
6. You	Be	Boy	Play	Up (adv)
7. He	All	Our	Day	Home
8. On	See	Man	Have	Made
9. No. (adv)	Go	Come	Big	Red
10. No (adj)	At	A	Run	Eat

TABLE 10.

A useful vowel list, and the frequency of appearance in the English language. (The columns outlined with heavy black lines are the words recorded for the test).

Vowel	Key	Pm	Frequency of use	Rating	Alternatives	"Repeat each sentence after you hear it"
u	tool	22	1.89	8	Boot, boon	What is a tool?
u	took	32	.71	12	Book, buck	He took the train.
o	tone	33	1.63	7	Bone, boat	Do you like the tone?
o	talk	37	1.35	11	Bought	Can animals talk?
o	ton	29	6.33	2	Bog, box	Coal is sold by the ton.
a	top	50	3.3	5	Bar, bark	The boy plays with his top.
a	tap	43	3.95	3	Back, bat	I heard a tap.
e	ten	25	3.44	4	Bet, beck	He gave her Ten.
a	tape	21	1.84	9	Bake, bait	He wrapped it with tape.
i	tip	32	8.53	1	Bit, bin	It was on the tip.
e	team		2.12	6	Beat, bean	John made the team.
i	time		1.59	10	Bite, bike	What is the time?
ou	town				Bout, bough	Do you live in town?
u	tug				Bug, but, bun	He gave it a tug.

Pm,—Acoustic Power in microwatts for eight male voices.

Dr. Macfarlan's records Nos. 5074 and 5075. (After Saccia and Sivian, Bell Telephone Laboratories.)

TABLE 11.

Speech Interpretation.

Fletcher's Vowel Sounds (Repetitions Omitted)	Fletcher's Consonant List (Repetitions Omitted)
Bike	Vie
Bat	**By** (71)
Bite	High
Boot	Wing
Beat	Thy
Boat	Wiz
Bake	Wig
Bout	Win
Bit	Shy
Book	**Why** (222)
But (206)	**Wish** (242)
Bait	**Which** (208)
Back (141)	Wick
Balk	Pie
Bet	Thigh
Bought	**With** (272)
Beak	Die
Bake	Lie
Buck	Wry
Beck	Tie
	Fie
	My (25)
	Whiff
	Sigh
	Will
	Whip
	Wit
	Guy
	Nigh
	Whim

The above 20 words and repetitions of them are used until 50 test words are given. If the vowel sound is reported correctly, the response is marked correct.

The words in black are those found among the first 500 for frequency of use. The numbers represent the rating in the "First 500" Word List.

(One objection to these lists is the unfamiliarity of many of the words used.)

TABLE 12.

Speech Hearing.

Bell Laboratories Articulation Test Record No. 84034A. (Vowel Word)

English Word List. Caller: E. L.

	Boot	961	Beat		Bike	762	Bit
83	Book	761	Bit		Balk	1223	Bought
1223	Bought		Bout		Bike	83	Book
761	Bit	916	Beat	762	Bit		Bate
83	Book	1066	Bite		Bough		Bat
	Beck		Bat		Bake	208	Boat
	Bake	961	Beat	1066	Bite	141	Back
	Bout		Beck	83	Book		But
141	Back		Bate		Boot		Buck
208	Boat		But	961	Beat		Boot
1066	Bite		Buck		Bet		Bate
	Bout	208	Boat	208	Bout	208	Boat
							Bout
							Bet

The numbers (inserted) represent the rating as to frequency of words used in the English language (Gates). The words in black are duplicates of previous words. (Sixteen words different; the rest, duplicate.) This list is identical as to content, but not order, with that appearing as the interpretation test by H. F. in Bell Laboratories Record, Oct., 1937.

TABLE 13.

Bell Laboratories Articulation Test Record No. 84034R. (Consonant Word)

English Word List. Caller: E. L.

Thigh	Die	Wish	Vie	Tie
Guy	Sigh	Thigh	Will	
Fie	Thy	Fie	Wye	
Wig	Tie	Sigh	High	
Shy	Whim	Sigh	Lie	
Rye	Rye	Shy	Which (witch)	
Nigh	With	My	Wye	
By	Wing	High	Pie	
High	Whim	Wing	Die	
Win	By	Thigh	Wip (whip)	
Thy	Wick	Which	With	
Win	Wick	Vie	Wiff (whiff)	

THE USE OF WORD LISTS FOR TESTING THE EFFICIENCY OF HEARING AIDS.

Table 14 represents Harvey Fletcher's method of grading a hearing aid. "In the absence of this record, on which this list is recorded, a microphone circuit may be used." The author prefers one of the many consonant level word records played out over a loud speaker. A graded intensity control is in the line. This allows the examiner to determine the amount of "boost" given by the hearing aid.

TABLE 14.

Fletcher's Intelligibility Test for Rating Hearing Aids (Bell Lab. Record, Oct. 1927).

(Pronounce the words in a natural voice, three feet from the hearing aid.)

FIFTY VOWEL SOUNDS.

Record as correct the proper repeating of the vowel sound only.

Bike	Bait	Bet	Beat	Bit
Bat	But	Bought	Boat	Book
Bite	Bout	Bat	Bait	Bet
Boot	Bit	Bite	*But (206)	Bought
Beat	Book	Boot	Bout	Back
*Boat (208)	Back	Beak	Bit	Bite
Bake	Balk	Boat	Book	Boot
Bout	*Back (141)	Bake	Beck	Beak
Bit	Bike	Buck	Balk	Boat
*Book (83)	Boot	Bout	Bait	Buck

Score:

Total correct out of 50 = x 2 = % Correct Vowel Interpretation (A).

FIFTY CONSONANT SOUNDS.

Record as correct the proper repeating of the consonant sounds only.

Vie	*Wish (242)	*With (272)	Thigh	Wit
*By (71)	*Which (208)	Die	Fie	Guy
High	Wick	*Lie	*My (25)	Nigh
Wing	*Pie (390)	Wry	Sigh	Shy
Thy	Thigh	*Tie	Vie	Why
Wiz	*By (71)	Which	Die	Fie
Wig	High	Wick	Will	Whim
Win	Wing	Pie	Wry	Sigh
Shy	Thy	Thigh	Tie	Vie
*Why (222)	Wiz	Whiff	Whip	Sigh

Score:

Total correct out of 50 = x 2 = % Correct Consonant Interpretation (B).

Multiply the Per Cent Correct Vowel Sounds by the Per Cent Correct Consonant Sounds and again by the Per Cent Correct Consonant Sounds. The result is a merit figure which represents the efficiency of the hearing aid. (consonants contribute twice as much to intelligibility as do vowels). A x B x B = Merit Rating.

Another Method of Rating the Efficiency of an Aid (from a case history):

Miss Z. wishes to know if a M---terphone with a BC receiver will help her.

(Setup of the test, — Phonograph; Records; Decibel Meter; Loudspeaker. Patient is at six feet from loudspeaker.)

There is a 15 to 18 db. loss in each ear.

Without the hearing aid the patient's performance is,—

Vowels.....100% correct Consonants.....52% correct

*Words marked with an asterisk are the only ones found among the first 500 words as to frequency of use. Their rating is numerically expressed.

(Rating, according to the method of crediting consonant-hearing as twice as important as vowel-hearing),—

1. x 0.52 x 0.52 .2704 or 27%

* * * *

Using a hearing-aid, set at an intensity "that satisfies" her, the result was:

with BC receiver,—Vowels .....100% correct
Consonants ..... 74% correct
Rating,— 1 x .74 x .74 .5476 or 54%

* * * *

With the same hearing-aid, using its AC receiver, the vowels were not heard up to 100% correct, and the consonants were heard very poorly. No rating made.

* * * *

With another aid using a Brush crystal phone, she showed:
Vowels.....100% correct Consonants.....78% correct
Rating,— 1 x .78 x .78 .6064 or 60%

Mr. Strohm, the engineer of the Dictograph Products Corporation, has suggested an ingenious record, which, by the selection of words, may show up hearing efficiency in high or low tones.

TABLE 15.

Articulation Test (Strohm).

Low Freq. Word List	Without Aid	With Aid	Low Freq.	High Freq.	High Freq. Word List	Without Aid	With Aid
Bet					Which		
Why			100		Guy		
Boat			50		Wiz		
My			50		Sigh		
Bout			70		Wick		
By			60		Pie		
Boot			30		Nigh		
High			40	•	Shy		
Bought			30		Tie		
Lie			30		Fie		
			10				
			0				
			1,500 C. P. S.				
	%	%				%	%

Note: Words are marked as correctly received if sound represented as printed in black is recognized.

Low frequency words (black sounds) give 95 per cent articulation if all frequencies ABOVE 1,500 cycles are removed. High frequency words (black sounds) give 95 per cent articulation if all frequencies BELOW 1,500 cycles are removed.

About 1938, Arthur M. Wengel, a radio engineer, brought out a test with speech sounds designed to determine the type of correction needed from an aid, in order to give greatest hearing efficiency:

"THE WENGEL AUDIOSELECTIVE HEARING TEST."

"The word test consists of three groups of words. The first contains 15 pairs of carefully selected words in like combinations testing the perception of, and discrimination between, voiced and voiceless consonants; the second, 15 pairs of words in like combinations, testing the perception of, and discrimination between, vowel resonances; the third, 30 pairs of words in like combinations, testing the perception of, and discrimination between, high frequency consonants.

"After the audiometer test, the patient is given an earphone connected to the test auditor*; he is also given a copy of the word sheet. The frequency response adjustments on this instrument are set to approximately compensate for the patient's hearing loss according to his audiogram. One of each pair of words of like sound is spoken into the microphone, and the patient marks on his sheet the word he thinks he hears. The words are spoken in a conversational tone, if anything a little slower than is usual in average conversation, and about three feet away from the microphone. An excellent method is to watch an oscillograph to keep the voice level constant. From 80 per cent to 90 per cent, according to the degree of deafness, and other characteristics of the case, is considered a very good average for this word test, since persons with normal hearing often find it difficult to discriminate between some of these speech sounds; however, it is not unusual to have 100 per cent correct response when the patient's mental reactions are normally keen and the frequency response is adjusted accurately to his condition.

"This fitting is then checked by trying the word test with other frequency response adjustments. This will often drop the accuracy of response from 10 per cent to 40 or 50 per cent.

*The Wengel Test Auditor is a calibrated instrument producing pure sine waves at all frequencies, and completely adjustable as to frequency response combination, intensities of sound and dampener effect.

In many cases inaccurate fitting as to frequency response will make speech entirely unintelligible. This, then, is a startlingly impressive demonstration of the efficacy of perfect fitting. The patient is further checked for the understanding of speech at a distance; for the understanding of male and female voices; and sometimes a check is made by the use of music or all-frequency records. This test also indicates the degree of accommodation to intensities of sound, the mental reflexes, and other conditions and reactions as previously mentioned."

TABLE 16.

Wengel's Test Blanks.

	A.	
1. fan-van	1. race raze	1. cat-gut
2. rack-rag	2. cat-gat	2. dell-tell
3. tin-din	3. but-putt	3. hiss-his
4. bat-pat	4. dire-tire	4. fairy-very
5. sip-zip	5. vine- fine	5. bat-pat
	B.	
1. tall-tell	1. ball-bell	1. fall-fell
2. rat-rot	2. bat-bought	2. cat-cot
3. slip-sleep	3. hip-heap	3. dip-deep
4. tin-ten	4. bin-Ben	4. din-den
5. jeet-heat	5. boot-beat	5. moot-meat
	C.	
1. myth-miff	1. thigh-fi	1. snow-Sue
2. breathe-breeze	2. so-show	2. lathe-lave
3. writhe-rise	3. dub-dug	3. kill-pill
4. sing-thing	4. load-lobe	4. frill-thrill
5. loaf-loath	5. rat-rack	5. can-tan
6. mass-mash	6. D-B	6. van-than
7. sour-shower	7. tie-pie	7. those-zose
8. vine-thine	8. cat-cap	8. pass-path
9. that-vat	9. thin-fin	9. thimble-fimble
10. half-hath	10. pine-tine	10. see-she

Readings.

Volume		
Highs		
Lows		
Dampener		

DR. ROBERT WEST'S WORD LIST.

In 1938, Josephine N. Timberlake reported in the September *Auditory Outlook* a word test invented by Dr. Robert West, Professor of Speech Pathology at the University of

Wisconsin. Groups of words have been listed which lie in various frequency zones, thus the test is one of so-called "selective amplification."

"Each of the three vertical columns constitutes a complete test. The reader and the listener should each have a copy. The reader, a person with clear, distinct speech, should speak in a natural, conversational tone, about four feet from the microphone. The listener should keep his eyes on the test,—no lip-reading allowed. The reader should pronounce one of each pair in column 1, checking it as he does so. The listener should check the word he thinks he hears. When the column has been read, the two should be compared. Each correct word counts four. If your hearing aid is giving you good service, you should be able to score above 70, and if it is one of the best on the market, and really suited to your case, you may be able to score above 90. I have seen scores of 90 to 100 made repeatedly. The other two columns may be used for other tests, or checkups."

TABLE 17.

Dr. Robert West's Word Tests for Hearing Aids.

Fundamental or	1.	2.	3.
Voice Range	fan-van	fine-vine	ferry-very
100 to 400 vibs.	rack-rag	sack-sag	back-bag
per second.	pat-bat	pin-bin	bill-pill
	tin-din	ten-den	toe-dough
	sip-zip	seal-zeal	zinc-sink
	thy-thigh	thy-thigh	thy-thigh
Vowel Range	see-Sue	tea-too	she-shoe
350 to 2,400 vibs.	brick-brook	look-lick	took-tick
per second.	break-broke	boat-bait	gate-goat
	tell-tall	ball-bell	fell-fall
	cab-cob	black-block	sack-sock
	rah-raw	la-law	ha-haw
Semi-Vowel Range	wed-red	rig-wig	will-rill
400 to 4,000 vibs.	lay-ray	lice-rice	lock-rock
per second.	you-Lou	yet-let	yes-less
Nasal Range	knob-mob	night-might	gnat-mat
600 to 2,600 vibs.	sing-sin	rang-ran	fan-fang
per second.			
Consonant Range	wreath-reef	deaf-death	sheath-sheaf
2,000 to 8,000 vibs.	pin-tin	ten-pen	pan-tan
per second.	car-tar	tall-call	till-kill
	cat-pat	coal-pole	coast-post
	that-vat	thine-vine	thou-vow
	so-show	sign-shine	sell-shell
	breathe-breeze	teethe-tease	close-clothes
	think-sink	sank-thank	thin-sin

THE KNUDSEN-WATSON "ARTICULATION" LIST.

In April, 1940, two leading acoustic research workers, L. A. Watson and Vern O. Knudsen, published in the *Journal of the Acoustical Society of America*, a classical article on Selective Amplification on Hearing Aids. Under Chapter 3 appears: "Criterion, Articulation Lists, Laboratory Apparatus, Technique of Testing," which for the sake of accuracy and completeness is copied verbatim, without deletion or editing.

III. Criterion, Articulation Lists, Laboratory Apparatus, Technique of Testing:

The criterion adopted for evaluating the effectiveness of the various types of amplification is based on the percentage syllable articulation, calculated according to the formulas developed by Fletcher and Steinberg.

As the base for the articulation lists to be used in these tests, a group of words was prepared by L. W. Sepmeyer modeled after that compiled by Fletcher and Steinberg. It contains sixty-nine words. Of these, twenty are "vowel" words, *i.e.*, one-syllable English words each incorporating an English vowel sound between the consonants b and t or b and k; the remaining forty-nine are "consonant word, *i.e.*, one-syllable English words each containing an initial consonant before short e or long i or a final consonant after short i. Table 18 gives a typical seventy-five word articulation list with the phrases used to introduce each group of three words. The sound to be tested by each word is underlined.

In order to insure a source of these speech sounds of standard accurately reproducible intensity and quality, phonograph recordings of sixteen different arrangements of the test words were made under the supervision of Mr. Sepmeyer. The recording system was accurately calibrated as to frequency response. The phonograph-amplifier system used to reproduce the recordings has a frequency response curve such that when the recordings are played over it, the words reach the listener uniformly amplified or reduced from the level at

which they originally were spoken, except when controlled variations are introduced into the amplifier system to provide selective amplification. An extensive set of frequency distortion networks is used for this purpose.

The listener, or observer, is situated in a room which is so nearly soundproof that he can hear nothing but the test sounds coming through the earphones. This is true even for observers with normal hearing.

The threshold level for speech for each ear is determined by the observer listening to the articulation lists in the following manner: The operator controls a noiseless switching device so that only the test words are heard in the earphone, the introductory phrases being cut out in each case. The observer is instructed to signal for each word he hears. The operator first sets the attenuators at a level such that the observer can hear all three words faintly; then he decreases the intensity by 1½ db. after each group of three words until the observer can no longer hear any of the words. A complete record of the response or no-response for each word is kept. The operator then increases the intensity by 1½ db. steps, until an intensity is reached at which the observer hears all three words. The process is then repeated for the remainder of the list, so that a total of seventy-five words is used to determine each threshold. Usually this means that approximately 15 words are presented to the observer at each level close to the threshold. From these results the threshold level is chosen as the lowest level at which the observer responds to more than half of the words presented at that level. Tests are then conducted at various levels above the threshold, obtained by removing attenuation from the amplifying system. As the listener-observer hears the successive groups of three words, he writes them on a special form. The list is then graded and the percentage syllable articulation calculated from the correct Fletcher-Steinberg Formula for the type of list given in Table 18; namely,

$$S = \left\{1 - \left[1 - \frac{V}{100}\left(\frac{C}{100}\right)^2\right]^{0.9}\right\} 100$$

Where S is the percentage syllable articulation, V is the percentage of vowels correctly interpreted in the vowel

words, and C is the percentage of consonants correctly interpreted in the consonant words.

TABLE 18.

1. The first is	Bait	Set	Ret
2. Now try	But	Rip	Ben
3. Please repeat	Boat	Sty	Riff
4. Group 4 is	Bake	Guy	Win
5. The next is	Balk	Jen	Thigh
6. Now comes	Bat	Pen	Yen
7. Listen to	Bite	Rim	Let
8. Try to hear	Bet	Men	Ring
9. Next comes	Bought	Tie	Thy
10. Group 10 is	Book	Rick	Wing
11. Please repeat	Bit	Shy	Wick
12. Can you hear	Bout	Wry	Jet
13. Now try	Beat	High	Yet
14. The next is	Boot	Net	Wen
15. Listen to	Beck	Vet	Will
16. Try to hear	Boot	Hen	Sigh
17. The next is	Book	Fen	Rig
18. Now comes	Bike	Whiz	Pen
19. Now try	Back	Then	Rid
20. Group 20 is	Bit	Rich	With
21. Listen to	Bout	Rib	Ten
22. Try to hear	Beak	Fie	Wish
23. Please repeat	Buck	Whiz	Whist
24. Next comes	Boat	Which	Den
25. The last is	Bark	Vie	Wet

Typical articulation list. The sound to be tested in each word is in black. Words are called in groups of three, each group preceded by an introductory phrase.

WORD AND SENTENCE LISTS FROM ENGLAND.

During the last decade there arose in England an intense revival of interest in the cause of the deaf. A small group of workers in Manchester (A. W. G. Ewing, T. S. Littler and I. R. Ewing) and in London (P.M.T. Kerridge) were the leaders in the work. Tables 19, 20 and 21, and the tables used by Miss Kerridge. The words and sentences represent a selection of a large variety of speech sounds. (Children in the five, six and seven-year groups would have difficulty from lack of familiarity with words in Table 19.)

TABLE 19.

Word Tests for Deaf People.

F	G	H	I	J
Scratch	Bears	Dole	Charm	Box
Beard	Germ	Part	Rate	Thought
Job	Nest	Gin	Yawn	Vat
Mouse	Sheaf	Choice	Pairs	Chairs
Gate	King	Set	Trip	Feet
Chief	Wood	Fears	Sock	Girl
Time	Void	Splash	Thud	Hook
Thief	Year	Hairs	Vote	Town
Shawl	Cheese	Risk	Jet	Pool
Desk	Rap	Vell	Spring	Whip
Noon	Prize	Church	Fool	Noise
Fox	Tide	Spurt	Coin	Name
Ring	Chum	Ride	Bush	Drive
Rush	Thing	Rock	Goat	Cash
Road	Food	Gang	Mat	Yacht
Yard	Knot	Docks	Mud	Bed
Fright	Cord	Tub	Guide	Fact
Voice	Shears	Thorn	Horse	Cheers
Pet	House	Youth	Fern	Joke
Ford	Cart	Ward	Weed	Hum
Tart	Rogue	Crime	Cheeks	Farm
Wool	Tax	Tomb	Wing	Side
Cares	Pail	Gown	Jeers	Board
Cat	Street	Fate	Dash	Scream
Herd	Debt	Book	Task	Gong

Use one vertical column for each test. Allot four marks for each word. Deduct one mark for incorrect initial sound. Deduct one mark for incorrect vowel sound. Deduct one mark for incorrect final sound. Deduct last mark if no sound is heard at all. (Ref.: Fry and Kerridge, Lancet, Vol. 1, 1939.)

TABLE 20.

Sentence Tests for Deaf People. Series A.

1. The woman sat in the park.
2. The boy did his homework.
3. The players deal the cards.
4. The girl gets a prize.
5. Sailors part from their wives.
6. Carpenters use a chisel.
7. The servant dropped the plate.
8. The artist draws a sketch.
9. The crowd looked at the queen.
10. The stranger asked the shortest way.
11. The furniture was moved in a van.
12. The fat child cut her thumb.
13. School children learn lessons.
14. The baker had some more bread.
15. The labourer loads the lorry.
16. Darkness frightens little children.
17. The housekeeper bought the food.
18. Hens have chicks in the spring.
19. The shepherd found the lamb.
20. The younger son joined the Air Force.
21. The crowd jeered at the speaker.
22. The maid took care of the clothes.

23. The bright sun thawed the snow.
24. The shopkeeper shows his goods.
25. The infant screamed with rage.

Use one series for each test. Allot four marks for each sentence. Deduct one mark for every word wrong. (Ref.: Fry and Kerridge, Lancet, Vol. 1, 1939.)

TABLE 21.

Sentence Tests for Deaf People. Series B.

1. The man drank his beer.
2. The boy took his grey coat off.
3. The mother needed a lengthy rest.
4. Cars skidded on the wet roads.
5. The agent let the old house.
6. Twelve months make a year.
7. The fat man mopped his brow.
8. The teacher marks the exercises.
9. The child was shown a picture.
10. The clergyman preached a long sermon.
11. The puppy chewed the ball of string.
12. Visitors come to tea.
13. The bus turned round the corner.
14. Smokers strike matches.
15. The gardener cuts the lawn.
16. The gamblers tried their luck.
17. A stitch in time saves nine.
18. The magistrate bound her over.
19. The woman burnt the cakes.
20. The family enjoyed the play.
21. The police feared a riot.
22. Soldiers wear uniforms.
23. The thief took the watch.
24. The black cat sharpened his claws.
25. The procession passed the house.

Use one series for each test. Allot four marks for each sentence. Deduct one mark for every word wrong. (Ref.: Fry and Kerridge, Lancet, Vol. 1, 1939.)

AN ACOUSTICALLY COMPLETE SENTENCE.

In a January, 1941, issue of the *Saturday Evening Post* appeared this interesting and instructive advertisement of the Bell Telephone System (quoted in part).

"Joe took father's shoe bench out. . . . She was waiting at my lawn."

If you were passing through the Bell Telephone Laboratories today you might hear an electrical mouth speaking this odd talk, or whistling a series of musical notes, to a telephone transmitter.

This mouth can be made to repeat these sounds without variation. Every new telephone transmitter is tested by this mouth before it receives a laboratory or manufacturing O. K.

for your use. This is only one of the many tests to which telephone equipment is subjected in the Bell Telephone Laboratories. And there is a reason for the selection of those particular words.

It happens that the sentence, "Joe took father's shoe bench out," and its more lyrical companion, "She was waiting at my lawn," contains all the fundamental sounds of the English language that contribute to the intensity of sound in speech.

Homonyms: Words alike in sound but differing in meaning.

Pair.....a pair of gloves	Bear.....to bear a burden
Pear.....a fruit	Bear.....an animal
Pare.....to peel	Bare.....unclothed

Homophone: A letter representing the same sound as another.

Homophenous: Words alike in sound. "Homophenous refers only to words confused in lip-reading," *e.g.*:

Chip.....ship	Wash.....watch
Were.....whir	Berth.....birth.....mirth
Oar.....or.....ore	Came.....cape.....game

L. CLYDE DWIGHT'S TEST.

In November, 1938, L. Clyde Dwight, a physiotherapist of Syracuse, N. Y., devised a selective hearing test and made a recording of the words used. He selected the test words for:

1. "A Voice range of 100-400." *2.* "A Vowel range of 400-2,000." *3.* "A Consonant range of 200-8,000." He called his record a "triple-test record."

A Dwight Electro Group Audiometer was marketed by The Audiometer Company, which had been associated with the Rototone Company. The conception of the test was worth while, but the word list seems entirely too small. One might question if it was practical to get a voice range of 100 to 400 cycles. (I know of no literature published by Mr. Dwight, but his correspondence and forms have been quite complete.)

PHONOAUDIOMETER TEST FOR HEARING.

Name .....
Age .....
Grade .....
Date .....

INSTRUCTIONS.

You will hear numbers and letters spoken by a person moving away from you. Then you will hear a column of words in average voice to

test your range of hearing. Always keep trying until the final signal words are given. In columns 4 and 8, check one word you hear in each space.

Decibel Loss Cols. 1-3, 5-7	Right Ear 1	2	3	4	Left Ear 5	6	7	8		Frequency Range Cols. 4 & 8
				Bag				Bat		
22	.....	.....	.....	Back	.....	.....	.....	Pat	25%	Voice
				Back				Bat		Range
20	.....	.....	.....	Bag	.....	.....	.....	Pat	25%	
				Bat				Back		100-
18	.....	.....	.....	Pat	.....	.....	.....	Bag	25%	400
				Pat				Bag		
16	.....	.....	.....	Bat	.....	.....	.....	Back	25%	
				Tee				Bait		
14	.....	.....	.....	Tea	.....	.....	.....	Boat	25%	Vowel
				Tea				Boat		Range
12	.....	.....	.....	Too	.....	.....	.....	Bait	25%	
				Boat				Tea		
10	.....	.....	.....	Bait	.....	.....	.....	Too	25%	400-
				Boat				Tea		2000
8	.....	.....	.....	Bait	.....	.....	.....	Too	25%	
				Death				Sin		
6	.....	.....	.....	Deaf	.....	.....	.....	Thin	25%	
				Deaf				Thin		Conso-
4	.....	.....	.....	Death	.....	.....	.....	Sin	25%	nant
				Thin				Death		Range
2	.....	.....	.....	Sin	.....	.....	.....	Deaf	25%	
				Thin				Deaf		2000-
0	.....	.....	.....	Sin	.....	.....	.....	Death	25%	8000

Decibel Loss ..... Decibel Loss .....
Right Range Loss: Voice ..... Left Range Loss: Voice .....
Vowel ..... Vowel .....
Consonant ..... Consonant .....

HISTORY.

Did you ever have an ache or pain in your ear..... Which ear..... When.....
Did you ever have a running ear..... Which ear..... When.....
Does it run now.....
Do you ever have noises in your ear, like buzzing, hissing or roaring.....
Which ear..... When.....
Have you a cold or sore throat at the present time.....

WORD HEARING TEST. (Alfred R. Thea, 1941).

In June, 1941, Alfred R. Thea presented as a thesis for his Master's degree at Washington University, a most thorough treatise on the speech-hearing test. It is unfortunate that it has never been published. Thea's word lists are selected with the utmost care: *1.* meaningful words selected, *2.* monosyllables used, *3.* Caroline Yale's Chart of Phonetic elements used, *4.* each vowel and consonant is presented in approximately its natural frequency in spoken language,

5. ninety-six words of the consonant-vowel consonant type are used, *6.* all the words are in accepted vocabulary lists, *7.* 48 words are spoken by the male voice, 48 by female.

The recording method is after that used by some earlier investigators (Wengel, West). The record sheets present blocks of three words which sound alike. The person tested draws a line through the word he believes he heard.

RIGHT EAR

Name..... Grade.....

Age..... Date.....

INSTRUCTIONS.

You are now going to have your hearing tested. A voice will speak one of the three words at the top of column 1. Draw a line through the word you hear. Go right on down the first column checking the word which you hear in each group. Listen carefully because the words will be spoken softly.

	Column 1	Column 2	Column 3	Column 4	
	pie	wash	shoot	talk	
30	**pipe**	whip	choose	tall	30
	pile	**wish**	**shoes**	dark	
	seat	warm	three	chair	
27	suit	**farm**	**these**	shirt	27
	seed	arm	cheese	**church**	
	house	nine	**fun**	mad	
24	**mouse**	tight	fan	**man**	24
	mouth	**night**	ran	pan	
	that	home	**wheel**	**top**	
21	than	**comb**	will	tub	21
	fat	coat	whip	tip	
	turn	**blue**	gun	want	
18	burn	blow	**girl**	**warm**	18
	learn	flew	curl	arm	
	nail	**nine**	**cake**	shoe	
15	name	line	cage	**zoo**	15
	tail	name	bake	sue	
	told	**bed**	thank	oil	
12	don't	fed	thing	boil	12
	toes	bat	**think**	**spoil**	
	pen	heel	did	could	
9	men	will	**dog**	**good**	9
	pin	**hill**	dig	wood	
	law	down	**bought**	**red**	
6	lawn	**town**	bat	ran	6
	torn	turn	caught	bed	
	just	shoot	**took**	took	
3	bump	**sheep**	take	**book**	3
	jump	sheet	cook	box	
	wish	**yard**	hose	sheep	
0	**whip**	card	**rose**	chop	0
	ship	year	road	**shop**	
	bad	**pot**	gave	Ruth	
−3	**bath**	pop	came	teeth	−3
	pass	pipe	**game**	**tooth**	

Score: Right Ear.....

LEFT EAR.

	Column 1	Column 2	Column 3	Column 4	
	top	not	shop	till	
30	rub	nut	sheep	tell	30
	tub	pot	shoot	tall	
	gave	boy	think	suit	
27	gate	ball	thing	shoot	27
	cave	boil	sing	soup	
	first	hear	chop	walk	
24	fur	your	stop	wall	24
	purse	year	shop	fall	
	sand	race	lost	you	
21	ran	vase	gone	do	21
	rat	face	lawn	few	
	dig	beat	sing	neat	
18	pig	night	ring	deep	18
	did	bite	silk	need	
	coal	fell	sent	put	
15	pole	sell	went	book	15
	told	fence	wet	cook	
	jump	safe	touch	rest	
12	just	sail	turn	yet	12
	dust	sell	much	yes	
	whip	more	gun	kiss	
9	wish	pour	gum	give	9
	which	door	come	kick	
	thought	found	bat	through	
6	caught	rock	path	shoe	6
	throw	round	pass	zoo	
	hid	took	mine	peach	
3	hat	look	mean	reach	3
	hit	lake	men	peep	
	pour	mice	shoot	wet	
0	door	nice	choose	went	0
	more	knife	sheet	sent	
	fold	then	face	down	
−3	salt	ran	race	town	−3
	sold	that	fast	turn	

Score: Left Ear.....

HISTORY

Is anyone in your family hard-of-hearing?.....

Did you ever have a running ear?.....

Do you ever have noises in your ear?.....

Did you ever have an earache or a pain in your ear?.....

Have your tonsils been removed?.....

Have your adenoids been removed?.....

HUGHSON-BODYCOMB LIST.

The late Dr. Hughson, working in conjunction with Margaret Bodycomb, of the Pennsylvania School for the Deaf, used the following word list for children:

One	Father	This
Two	Pie	Foot
Three	Coat	Rung
Four	Month	Spoon
Five	Zoo	Dog
Six	Toy	Love
Seven	Top	You
Eight	Date	
Nine	Cat	
Ten		

"The following sounds are embodied in these words":

a—broad as in father	o—long as in coat
a—long as in date	o—short as in rung
a—short as in cat	o—broad as in four
e—long as in three	u—long as in foot
e—short as in seven	oi—diphthong as in toy
i—long as in nine	
i—short as in this	

(The author questions the desirability of using words such as "Zoo, this, date, rung, love" with very young deaf children of the preschool age. Many of these children would not have any concepts, imagery or memory of these words.)

SENTENCE INTELLIGIBILITY LISTS.

Much may be said of the difficulties arising in using sentences in testing, but much can also be said of using words in their natural settings. Bell, in his early work on teaching language to the deaf, insisted that it be used not as vowel or consonant sounds, building up into words, then into sentences, but by using whole words and phrases in teaching. Words are much more easily understood when in sentences than when alone, for the context helps; yet, education, familiarity and extent of vocabulary all make for imponderables in measuring the basic acuity to words when not alone. It might be roughly estimated that words spoken in sentences are picked up at lower level of 10 to 20 db. than are single words.

Sentences are most useful in testing hearing aids, and they are preferably recorded and played back on the phonograph into a loud speaker. By this method, one is at least sure of identity of test repetitions. The most serviceable lists are those reported by K. P. Royce, of the Bell Laboratories, the first of which is here given as an example.

In using the lists, the patient's hearing is tested first without the hearing aid and then with it. A decibel meter gives the value of the boost in hearing which the aid brings. Seldom is the hearing improved more than 40 db., but one should always seek to obtain at least 20 db. gain.

It appears to be a distinct obligation upon otologists to be able to tell patients exactly how much an aid helps. It should not be guesswork.

A measured determination of the increased interpretation is all the more important because many patients prefer one aid over another on account of the quality of the speech rather than upon measured efficiency. It must be remembered that many deaf persons have become used to speech distortion, which they have come to regard as normal speech. What matters most is whether or not an aid gives them more words heard at lower levels. In this determination the otologist should play his part.

TABLE 22.

Intelligibility List No. 1.

1. Name a prominent millionaire of the country.
2. How large is the sun compared with the earth?
3. Why are flagpoles surmounted by lightning rods?
4. Give the abbreviation for January and February.
5. Name the tree on which bananas grow.
6. How often does the century plant bloom?
7. What description can you give of the bottom of the ocean?
8. Explain the difference between a hill and a mountain.
9. What is the chief purpose of industrial strikes?
10. Describe the shoes of the native Hollander.
11. Name some uses to which electricity is put.
12. What would cause the air to escape from a bicycle tire?
13. Where is more grain used, in the East or the West?
14. Tell what is meant by an Indian Reservation.
15. For what invention is Thomas Edison noted?
16. Name a State which has no seacoast.
17. Write the Roman numeral ten.
18. Explain the difference between export and import.
19. Explain why a corked bottle floats.
20. What substance is a good conductor of electricity?
21. Explain why Indians were afraid of firearms.
22. Explain the purpose of fire drills.
23. At what time do ocean waves become dangerous?
24. What medicine would you take to remedy indigestion?
25. What knowledge is covered by the study of astronomy?
26. Name a good restaurant in this vicinity.
27. What is the importance of large windows in stores?
28. Explain why a giraffe eats the foliage of trees.
29. How are pages of a magazine held together?
30. Explain why the name string-bean is appropriate.
31. Name a nearby city in which there is a shipyard.

32. Name a fruit which grows in bunches.
33. Which of our Presidents went to South Africa?
34. Why are wire springs used in beds?
35. Why are books bound in stiff covers?
36. Why did the home people conserve food during the war?
37. Name an insect that has a hard shell.
38. What symbol on the United States money stands for liberty?
39. What weapons did the Indians use in warfare?
40. In what kind of weather does milk sour?
41. What streets in this city have Dutch names?
42. How does turning a ship's wheel steer the ship?
43. What nation aided us in the Revolutionary War?
44. What are some personal characteristics of the people of Japan?
45. What candy is black and good for colds?
46. Name a famous Indian Tribe.
47. Why is this building lighted by reflected light?
48. Why are most lighthouses situated on rocks?
49. Give some ingredients used in soap.
50. Why is a house built of stone superior to others?

NONSENSE SENTENCES.

There is a distinct place and use for a group of so-called "Nonsense Sentences" in testing for speech hearing. The break-up in continuity of thought and the total absence of meaning tend to cancel out much of the guesswork and intelligence in interpreting. Table 23 represents a list of such sentences used by the author.

TABLE 23.

Nonsense Sentences.
Giraffes are protected by lightning rods.
Scissors cut holes in the clouds.
The river rolled over on its back.
Soft coal is too hard to eat.
There are no Tuesdays in Baltimore.
Radicals are indigestible.
Toothpaste is made of cotton.
Crows cannot taste seaweed.
Towels take too much time talking.
You cannot write with a hammer.
Butter breaks bones in barley.
Cannons crack creases in clothes.
Dogs drag dark duties.
Even eels eat envelopes.
Fat fish fry freely.
Goats cut corners greedily.

Can there be made a record with a level intensity? Yes. Example of such a record:

The intensity "throw" of the needle of a loudness-level meter in the author's attenuated number record:

(Spoken)	"Five Four"	(Throw)	33-29
(Spoken)	"Five Six"	(Throw)	30-28
(Spoken)	"Eight Five"	(Throw)	31-31
(Spoken)	"Six Four"	(Throw)	30-30

The other spoken numbers are comparable although dropped 3 db. with each succeeding group of four.

It must be remembered that in spite of the evenness of level, words vary in their interpretability.

DECIBEL HEARING LOSS TO SPEECH AND PERCENTAGE HEARING LOSS.

Since, in normal hearing individuals, there is a 100 db. span between correct speech hearing at the minimal threshold and the maximum loudness of speech that can be tolerated, it is obvious that decibel hearing loss to speech is equivalent to percentage loss. This statement might be questioned and debated by one who was referring to speech that theoretically might have very few low tones, or, less rarely, very few high tones; but both male and female voices show a sufficient percentage of both highs and lows to make the objections invalid. The author believes that this relationship between decibel loss and percentage speech is reasonably reliable and very serviceable in answering the frequent query put by patients, "How much hearing have I lost?" It is obviously difficult to explain the decibel to them.

THE FALLACY OF ATTEMPTING TO DETERMINE HOW WELL SPEECH IS HEARD FROM AN AUDIOGRAM.

The following three superimposed audiograms illustrate the futility of attempting to express the losses shown in audiograms in terms of percentage. *A* is the record of the right ear of a young married woman, 22 years of age. (The record for her left ear was much poorer than that for her right and needs no consideration here.) The average loss at 512, 1,024 and 2,048 is 55 db. This multiplied by 0.8 gives, according to the Western Electric formula, a 44 per cent loss for speech. By actual tests, this patient could not understand speech through hearing at all. If one spoke loudly close to the ear she complained that the voice was so loud that it was almost painful. Insofar as hearing speech is concerned, her loss is much closer to 100 per cent than to 44 per cent. She can hear and has learned to recognize the cry of her baby. She is a graduate of a school for the deaf and in conversation is entirely dependent upon lip-reading. She became deaf at the age of 15. If an examiner were to tell her that she had a loss

for speech of but 44 per cent, she would doubtless think him ignorant of the facts. A hearing aid salesman might promise, on the basis of the audiogram, to fit her with a hearing aid. If he were to guarantee a perfect fitting and not demand payment until she was able to understand conversation with the instrument, he would probably not be paid.

B is the record of a boy, 14 years of age. His deafness was congenital or acquired before correct habits of speech were formed, for his speech is very defective. According to the formula above, his loss for speech is approximately 58 per cent. (The average reading at 512, 1,024 and 2,048 multiplied by .08.) The record given here is for the left ear. The

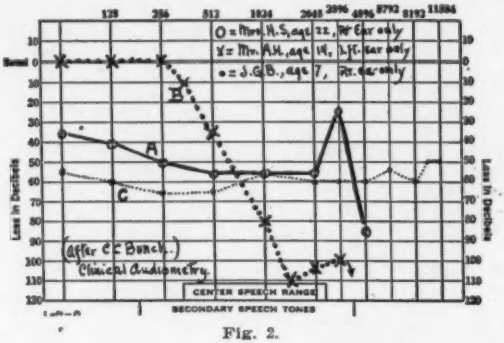

Fig. 2.

hearing in the right ear was almost identical. In tests for the spoken voice, if he knew that numbers under 10 were to be used, he could repeat them correctly at a distance of approximately 20 feet, but if the examiner stood close behind him and used miscellaneous words and sentences for tests, he would miss everything. Inability to carry on conversation at a distance of two or three feet certainly represents a loss greater than 58 per cent.

C is the record of the right ear of a boy, seven years of age. His deafness was congenital. The loss was approximately the same in both ears. According to the formula, this boy's loss is 48 per cent. His speech is not defective and he can converse easily with one at a distance of three or four feet.

Of these three patients, the one who has the least percentage loss according to the formula had the poorest hearing for

speech. Dozens of similar cases might be cited (from C. C. Bunch, Clinical Audiometry).

It would be a grand thing if hearing was just a matter of how well the ear perceives a few octaves of pitch, and, although complicated enough, it would be a relatively simple matter if we had to concern ourselves, as far as hearing perception goes, with what takes place in the cochlear ribbon; but hearing is not so simple. We hear not single tones, but sound patterns, and the flash images that are produced are complex pictures. It takes two years of beginning-life to develop even a memory of these sound pictures. The central perceptive sphere becomes so efficient that it is appalling. The association of sounds and meaning is a miraculous phenomenon greater than vision. The appreciation of nuances of tone, inflection and emotion in speech, alone, shows the exquisite subtlety of hearing.

This being the case, we should not leave hearing-testing merely in the pitch discrimination zone. Certainly is this true when pitch hearing-testing tells us nothing as to how well speech is heard. Basically, and finally, it is speech with which the ear is concerned.

Herewith is a factual comparison of speech-hearing testing and tone audiometry, which is submitted because there are still many otologists who think that the audiometer, as we know it and use it, is sufficient. The record is not one made by myself but by another worker, totally independent of any suggestion from me. She uses three readings on each subject: *1.* a frequency run; *2.* the deduction from the frequency run of what speech hearing is to be (Fletcher's method); *3.* phonographic audiometry or speech-hearing testing with speech used as a test stimulus. It must be said that although Fletcher's method of averaging has been outmoded, the principle is the same as that recommended by the American Medical Association Council where more care has been given to the "weighting" (relative importance) of the various frequencies in the speech range. The total lack of correlation shown in these readings will be immediately obvious. The conclusion is that we had best stick to speech if we are to determine how well speech is heard.

A COMPARISON BETWEEN THE PHONOGRAPH AUDIOMETER (4A) AND THE WESTERN ELECTRIC PITCH AUDIOMETER (2A).

A series of 12 cases tested by Miss Ethel Warfield, of the New Jersey State Department of Public Education, and special worker with the deaf and hard-of-hearing.

The tests were made in an "ordinary" room, not soundproofed, but relatively quiet. As an index of the noise level, and the "set" of the testing conditions, a composite audiogram of the normal hearing was made.

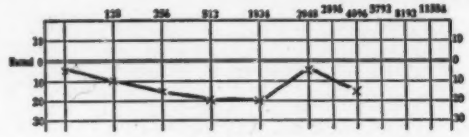

Fig. 3.

(Harvey Fletcher deduced the speech hearing loss by averaging the decibel loss for the pitches, 512, 1,024, 2,048, and multiplying by the factor 0.83.)

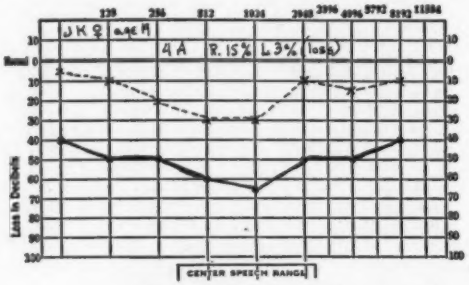

Fig. 4. J. K., ♀, Age 19.

4A. R. E.....15% loss (retesting). Fletcher deduction, 46.4% loss.
L. E..... 3% loss. Fletcher deduction, 13.28% loss.

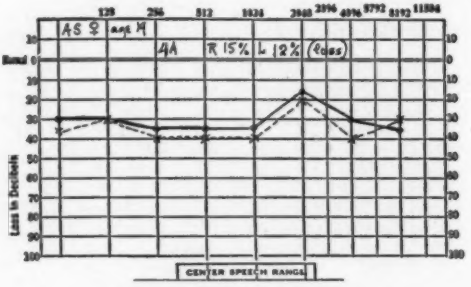

Fig. 5. A. S., ♀, Age 19.

4A. R. E.....15% loss. Fletcher deduction, 24% loss.
L. E.....12-15% loss. Fletcher deduction, 26.64% loss.

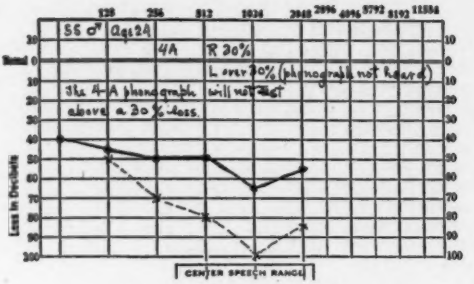

Fig. 6. S. S., ♂, Age 24.

4A. R. E. Heard only first numbers in two columns correctly (30% loss).
L. E. No hearing (the phonograph does not test above 30% loss).
Fletcher deduction: R. E.....48%; L. E.....69.6%.

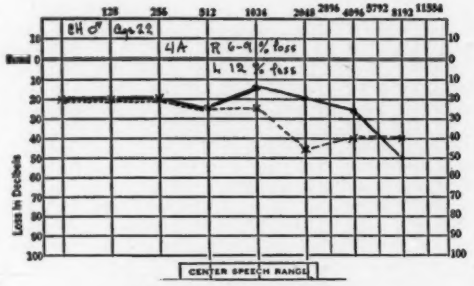

Fig. 7. E. H., ♂, Age 22.

4A. R. E.....6-9% loss. Fletcher's deduction, 16% loss.
L. E.....12% loss. Fletcher's deduction, 25-28% loss.

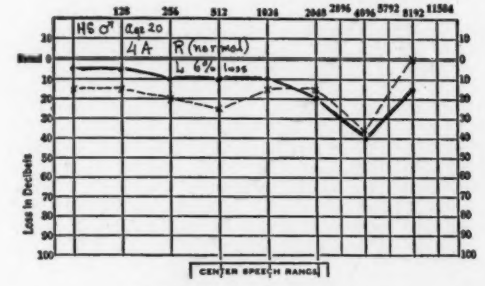

Fig. 8. H. S., ♂, Age 20.

4A. R. E.....normal. Fletcher's deduction, 10.64% loss.
L. E.....6% loss. Fletcher's deduction, 9.04% loss.

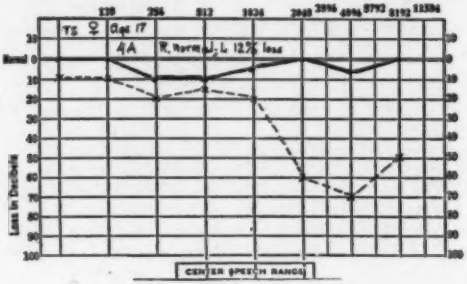

Fig. 9. T. S., ♀. Age 17.

4A. R. E.....normal. Fletcher's deduction, 4% loss.
L. E.....9% loss. Fletcher's deduction, 24.8% loss.

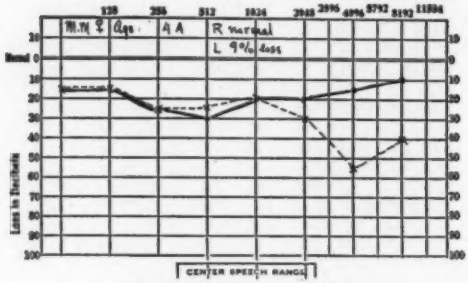

Fig. 10. M. M., ♀, Age 22.

4A. R. E.....normal. Fletcher's deduction, 18.4% loss.
L. E.....9% loss. Fletcher's deduction, 20% loss.

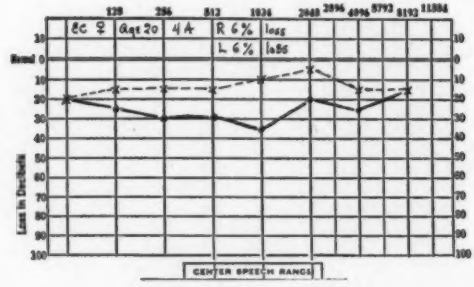

Fig. 11. E. C., ♀, Age 20.

4A. R. E.....6% loss. Fletcher's deduction, 22.4% loss.
L. E.....6% loss. Fletcher's deduction, 8% loss.

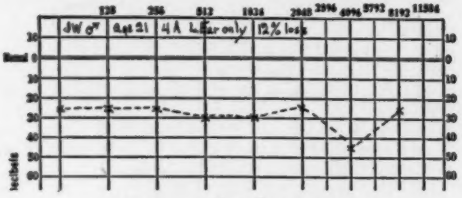

Fig. 12. J. W., ♂, Age 21.

4A. R. E.....(no record).
L. E.....12% loss. Fletcher's deduction, 22.4% loss.

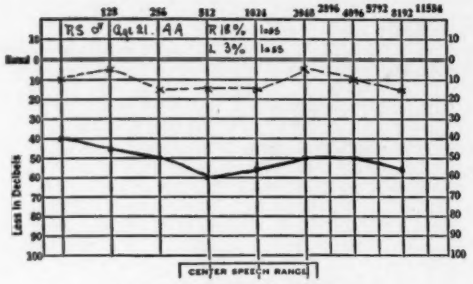

Fig. 13. R. S., ♂, Age 21.

4A. R. E.....18% loss. Fletcher's deduction, 44% loss.
L. E..... 3% loss. Fletcher's deduction, 9.6% loss.

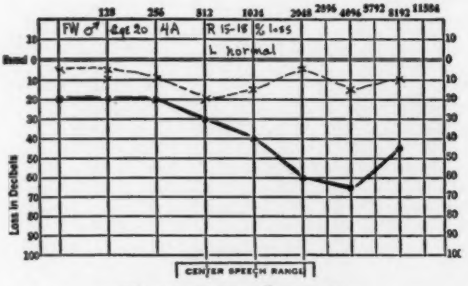

Fig. 14. F. W., ♂, Age 20.

4A. R. E.....15-18% loss. Fletcher's deduction, 36.64% loss.
L. E.....normal. Fletcher's deduction, 10.64% loss.

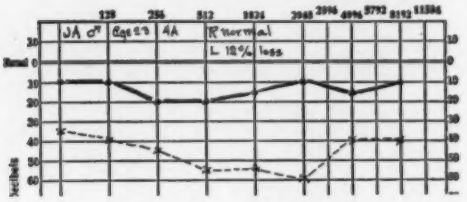

Fig. 15. J. A., ♂, Age 23.
4A. R. E.....normal. Fletcher's deduction, 12% loss.
L. E.....12% loss. Fletcher's deduction, 45.28% loss.

Conclusions: Twenty-one comparisons between the two methods of determining speech-hearing show that there is a variation in the ratio 22:9 in favor of the frequency audiometer presuming greater hearing loss.

* * * *

It is common experience for one who makes a point of doing both frequency testing and phonograph audiometry on patients to find no correlation between the two tests. The phonograph usually shows up better hearing than one would incline to believe from first taking a frequency run; but this is not invariably true, and the reverse may be found.

* * * *

Demonstration of a finer testing and a better response to speech-hearing tests with a constant intensity record and a decibel meter as compared with the 4A technique.

Patient	Constant Intensity Record	4A 2 Number Record
J. D.	R..... 41% loss	60
	L..... 35% loss	60
H. F.	R..... 41% loss	54
	L..... 39% loss	50
R. M.	R..... 15-18% loss	22-28-34
	L..... 27-30% loss	46 52
D. W.	R..... 21% loss	42
	L..... 3% loss	46
L. O.	R..... 58% loss	58
	L..... 58% loss	58

For the constant Intensity Record, a decibel meter with 3 db. steps was used.

SUMMARY AND CONCLUSIONS.

This presentation of the consecutive development of word lists and of testing methods for speech-hearing is, as far as the author is aware, a complete list to date. One can readily see that much thought has been given a subject that has been largely overlooked by otologists. The contributions have been made for the most part by acoustic engineers, physiologists and educators.

Data is presented to show that *definitely* it is impossible to determine how well a person hears speech, from studying a frequency audiogram. This fact alone should re-establish measured-speech-hearing-testing with the otologist. It is also not without importance that an otologist should be equipped and ready to classify hearing aids for deafened persons. A number of tests for the speech hearing of little children is eagerly recommended for the importance of catching deafness before the school age.

Fortunately, the quality of acoustic circuits has reached a point of remarkable perfection and fidelity, so that no longer is the investigator working with poor quality speech; and the decibel meter has made it possible to accurately measure speech loudness. The importance of speech-hearing makes it essential to test quantitatively the hearing of speech.

The author has made another and more recent study (unpublished) of comparative findings with the ratings of "Percentage Loss" given by various formulae. It may now be said that the "weighting" of frequencies is undoubtedly improving towards proximal accuracy. The record below is that of but one patient, but will serve as a pattern for the large group tested. In No. 1 each ear was tested by the phonograph audiometer using headphones; then the hearing "with both ears open" was taken by using a loud speaker in place of the 'phones ("open air method"). In Nos. 2, 3 and 4 the frequency-audiometer findings were computed after the methods of Fletcher, Fowler and the American Medical Association Council. Fletcher's early method merely averages the loss in the middle frequencies and multiplied by 0.83. The other methods gave a definite value to each of the frequencies in the speech range, and, further than this, offered a formula for binaural hearing.

Mrs. T. (Using Speech)	Right Ear	Left Ear	Both Ears
1. Constant Intensity phonograph record varied in intensity by a decibel meter (see footnote)	40 db. loss 40% loss	25 db. loss 25% loss	30 db. loss 30% loss (by actual test)
2. Fletcher Method (using frequencies)	29% loss	36% loss	(no method advised)
3. Fowler Method (using frequencies)	36% loss	43.7% loss	31.5% loss (computed)
4. A. M. A. Method (using frequencies)	31% loss	38% loss	32.7% loss (computed)

ADDENDA.

Since the reading of this paper, the Maico Company has put on the market a phonograph audiometer with four records. "Record No. 2109-2110 is a double-sided recording which provides four columns of paired numbers on each side. The intensities are attenuated from 30 db. to 3 db. above normal. Record No. 2316-2317 uses selective words instead of numbers." A picture sheet with four columns for each ear offers a choice in each column of three objects which sound alike in pronunciation except for consonant elements,—*e.g.*, "stone, phone, bone." The child being tested merely checks which one of the three objects he believes he heard named. The records are attenuated intensities. The test words are chosen to detect cases of high tone hearing loss from 1,024 to 4,096 cycles.

Another word list comes to attention from Central Institute for the Deaf, St. Louis. The lists are composed of words and sentences used in that institution for auricular training; they are marked confidential, but do not show any unusual characteristics. (These lists are not to be confused with those of the "Word-Hearing Test" of Alfred R. Thea, compiled in 1941 (unpublished) when he was at Washington University.)

In September, 1942, Stanley Osserman (Board Chairman) and Mr. Strohm (Engineer), of the Dictograph Products Corporation (Acousticon Hearing Aid), showed me the plans for a selective speech hearing test, and submitted the word list seen in a preceding page. In the autumn of 1944, this work had matured to the point of "near" completion, and a considerable advertising campaign was started. Claims of marked originality were made, which cannot be supported when one studies the previous work by many investigators

along these lines. The advertising matter published two sheets of selective test words, but the phonograph records which were to be used were not obtainable when last requested.

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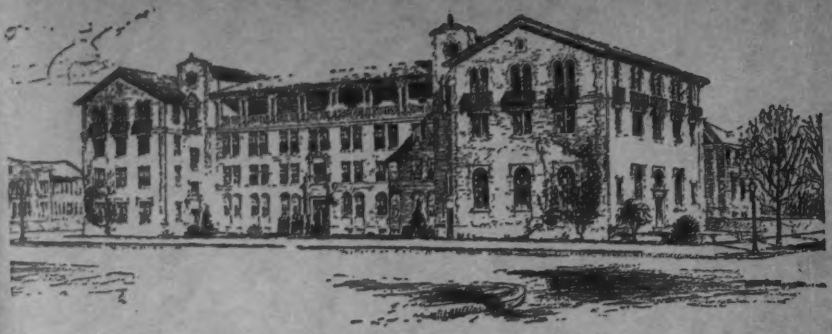

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